Essential Science 2

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BOOK 2

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by Charles Windridge

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Author's note

We are living in an age of scientific discovery and achievement. To a large extent, our way of life is governed by machines and technical processes. Therefore, it is very desirable that, when youngsters leave school, they should possess that kind of scientific knowledge which will enable them to understand and appreciate the work of the scientist and its many everyday applications.

The books in this series provide a course in general science for children in secondary schools. Every effort has been made to ensure that the contents are interesting and attractive and truly relevant to the needs of the pupil. The illustrations are bold and colourful. The language used is simple and direct.

The practical work is straightforward and homely and can be performed with the simplest apparatus. This means that the books could be particularly useful in those schools where laboratory facilities are not available.

The written work is at a minimum and consists of word lists, completing sentences, labelling drawings, brief descriptions, etc. It is felt that the traditional technique for writing up experiments – apparatus, method, results and conclusions –, while suitable for pupils who are pursuing academic courses, is not suitable for the pupils for whom these books are intended.

Thanks are due to Mrs. L. Allen for her help.

C. WINDRIDGE

IMPORTANT NOTICE

This book, as with the other books in the series, has been fully "metricated and decimalized" in accordance with the Standard International System of Units (Le Système International d'Unitès), known, more simply, as SI, which has been adopted as the national measuring system in the United Kingdom.

Due consideration has been given to the recommendations of the British Standards authorities – the British Standards Institution, the Royal Society, the Association for Science Education, the Royal Institute of Chemistry, etc.

Some of the many SI fundamental, derived and supplementary units are:

Physical quantity	*unit*	*symbol*
length	metre	m
mass	kilogramme	kg
time	second	s
temperature (customary)	degree Celsius	°C
electric current	ampere	A
area	square metre	m^2
volume	cubic metre	m^3

Further information about SI units can be obtained from these publications:

Changing to the Metric System. Her Majesty's Stationery Office.
Metrication in Secondary Education. The Royal Society.
The International System (SI) Units 3763. The British Standards Institution, Sales Branch, 101 Pentonville Road, London N.1.
Physio-Chemical Quantities and Units. The Royal Institute of Chemistry.
SI Units, Signs, Symbols and Abbreviations. The Association of Science Education.

Contents

1 Water is important

Using water

Water is important to us because it has many uses. Some of them are shown opposite. Can you think of any other uses of water?

Water everywhere

Water is to be found almost everywhere. As well as the water in seas, lakes, ponds, rivers, canals and tanks, there is water in the atmosphere, soil, plants and animals.

As you know, the water in the atmosphere is called *water vapour*.

Soil that seems to be dry contains a little moisture which is taken in by the roots of plants. That is why growing plants remain green and fresh even when the weather is hot and dry.

Most of a plant or an animal is water. About 9/10 of a cabbage is water. Almost 7/10 of your body is water.

The water in a cabbage

Weigh a cabbage or a lettuce on a kitchen balance. What is its weight?

After a week, weigh the cabbage again. What is its weight now? What has happened to the cabbage? How much water has it lost?

Water for life

Living things must have water. Plants soon wither and die when they have no water. Seeds will not grow without water. A man lost in a desert dies from thirst if he cannot find water. Water helps animals to keep cool. When animals perspire, some of the heat in their bodies is used up and so they keep cool.

Water in plants

Plants give off water, but, unlike animals, they do not do this to keep cool. We say that animals *perspire* and plants *transpire*.

What happens is this. Water, with *mineral salts* from the soil, is taken in by the roots of a plant. The salts are food for the plant. The water and the salts pass up the stem into the leaves. The water evaporates from tiny holes on the surfaces of the leaves. In this way, water is entering and leaving the plant all the time.

Stems carry water

Place a white flower in a jar of water. Pour a little red ink into the water.

After a few hours, the flower will be pink. What does this show?

Plants transpire

Place a leafy twig in a jar of water. Pour a little *olive oil* on to the surface of the water so that none of the water will be lost by evaporation.

After a few days, you will notice that the level of the water in the jar has fallen. How has the water escaped from the jar?

MORE THINGS TO DO

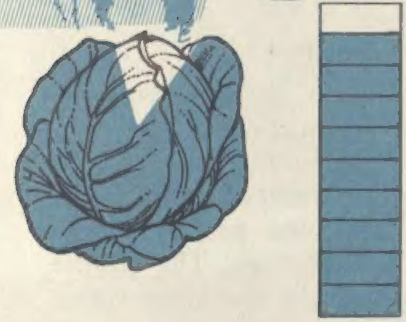
1. Copy the drawings shown in the black frames opposite. Do not draw the black frames.

2. Make a list of some of the uses of water.

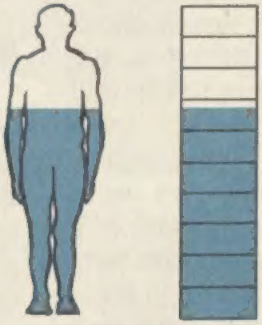
3. Write one sentence about each of these words in a way which shows that you know what the word means.

Atmosphere; perspire; transpire; evaporates.

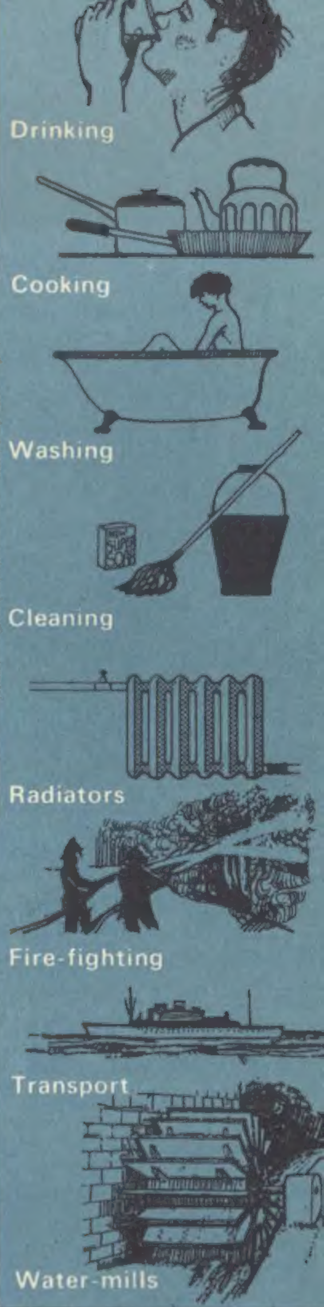
Water is important



About 9/10 of a cabbage is water



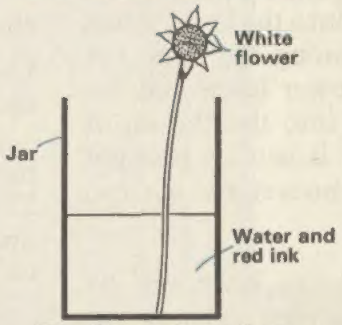
Almost 7/10 of a man is water



WATER EVERYWHERE

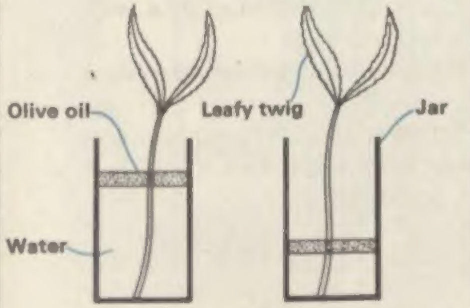
WATER IN A CABBAGE

STEMS CARRY WATER



The flower turns from white to pink

PLANTS TRANSPIRE



1. At the beginning 2. After a few days

WATER FOR LIFE

Animals perspire

Plants transpire

2 The water supply

The water supply

People in some country districts get their supply of water from ponds, lakes, springs, rivers and *wells*. But, there are many people in a large town or city and they could not depend on a few wells for their water supply. Also, ponds, springs and wells sometimes dry up in hot weather. And so, to make sure of a good supply of water even during a very dry season, river water is stored in lakes and *reservoirs*. A reservoir is an artificial lake which has been made by engineers.

Wells

Wells are deep holes in the ground.

Rain-water is soaked up by the ground and trickles into the lower levels where it collects among the rocks. A well reaches these lower levels and the water slowly drains into the bottom of the well. The water is usually brought to the surface by a bucket and a rope.

Dams

Engineers usually make reservoirs by building *dams* across river valleys.

When a dam has been built across a river, the water cannot escape and so it collects on one side of the dam.

The bottom of a dam is much thicker than the top because the weight of the water pressing on the bottom is much greater than that pressing on the top. The weight of the water pressing downwards and sideways is called *water pressure*. Sometimes, we say, "*water pressure increases with depth*".

Water pressure and depth

Use a hammer and a nail to punch small holes at different levels in the side of a biscuit tin.

Fill the tin with water. Water spurts from the holes. Which jet of water is the shortest? Which is the longest? Why is this?

How water is carried

The water in lakes and reservoirs is pumped to the districts where it is to be used and is stored in tanks on the top of *water towers*. The water flows from the tanks, under its own pressure, into pipes which lead to taps. The simple act of turning on a tap makes the water available.

The higher the water tower, the greater is the pressure of the water and the faster it will flow from the taps. The height of the water above the taps is called the *head of pressure*.

Head of pressure

Use a hammer and a nail to punch a small hole in the bottom of a can.

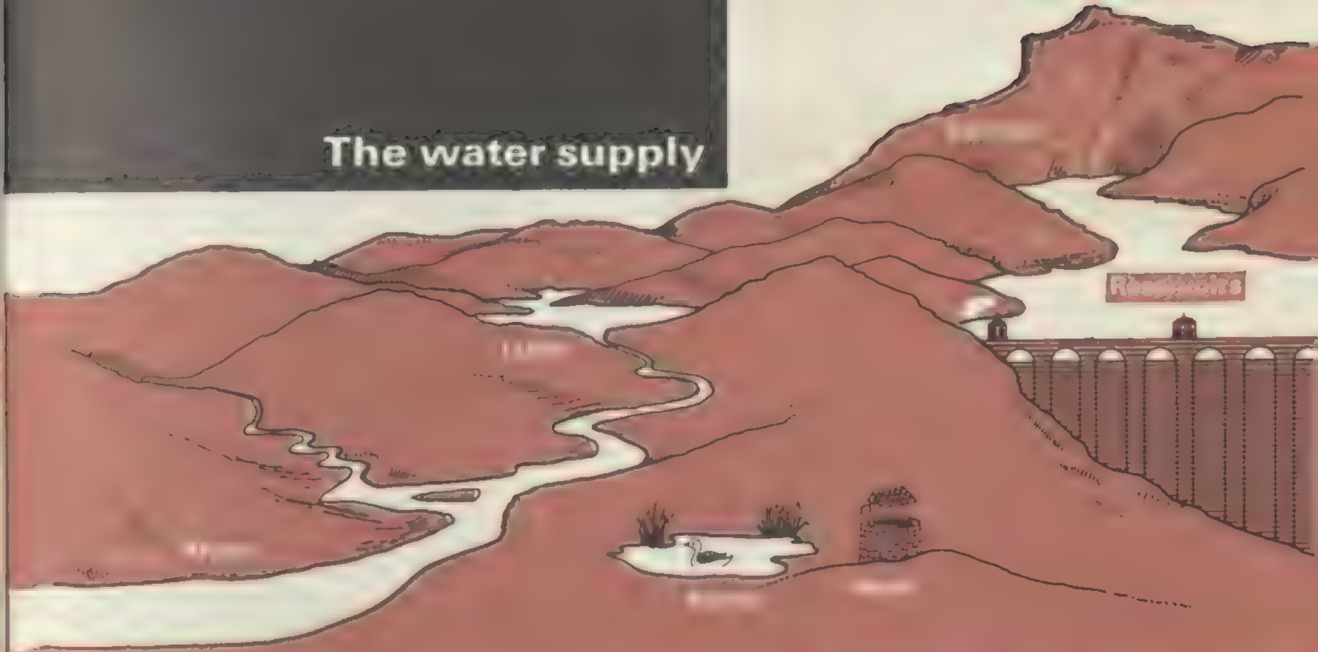
Stand the can in a bowl of water. A fountain of water arises from the hole. The height of the surface of the water above the bottom of the can is the head of pressure.

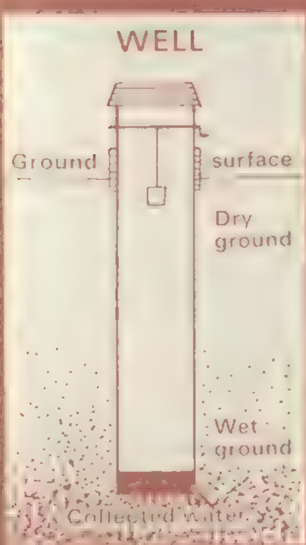
Raise and lower the can. What happens to the fountain? Why does this happen?

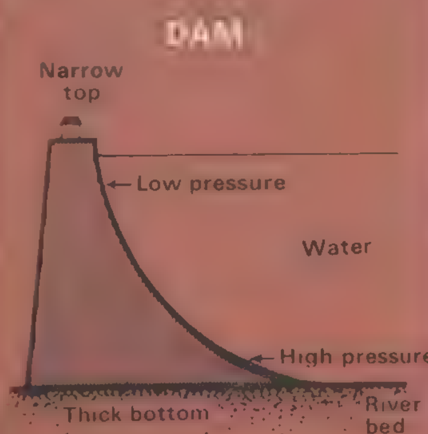
MORE THINGS TO DO

1. Copy the section drawings of a well, a dam and a water tower.
2. Copy the drawings shown in the black frames opposite.
3. Write a few sentences to explain why water spurts very quickly from a leak in a water pipe.

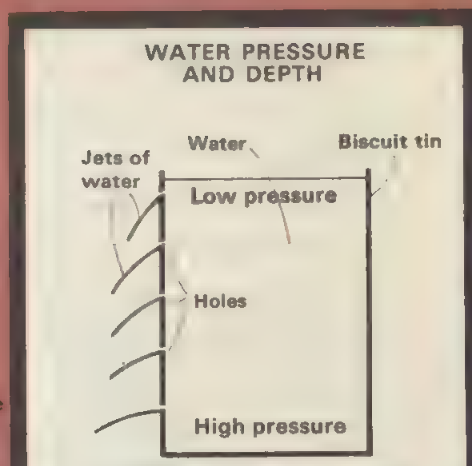
The water supply



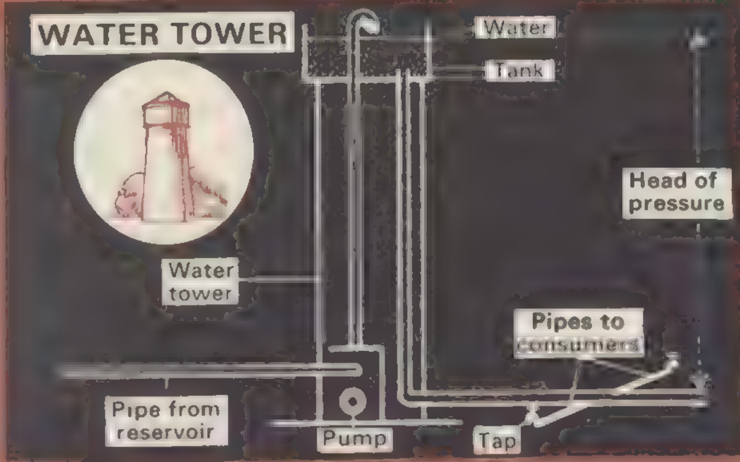


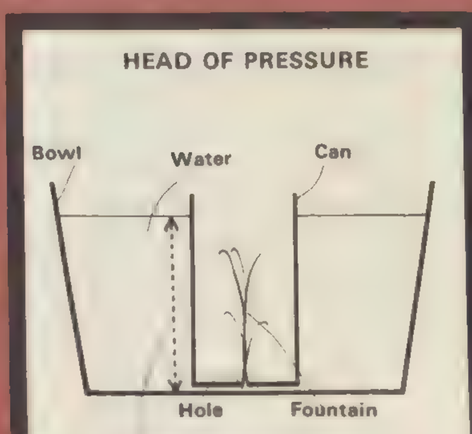


Water pressure increases with depth



Water pressure increases with depth





This distance is the head of pressure

3 Pure water

The impurities in water

The water stored in lakes and reservoirs contains such impurities as *germs*, tiny plants and animals, mud, mineral salts and rubbish of different kinds. Some of the germs could cause serious illnesses, decaying rubbish may give the water an unpleasant taste and smell, and the mud makes the water cloudy. Therefore, these impurities must be removed if the water is to be fit for drinking.

Most mineral salts are harmless and some are good for the health and so, usually, they are allowed to remain in the water.

Rain-water and dew are almost pure water but they do contain some impurities. It is not really safe to drink rain-water. Sea-water is not fit to drink because it is too salt.

Pure water

This is how pure water is made.

First, the water is pumped from the lakes and reservoirs into *settling tanks* in the districts where it is to be used. The water stands for a time so that mud and rubbish can settle. Also, oxygen in the atmosphere reaches the surface of the water and kills many germs.

Next, the water slowly trickles through a *filter bed*. Tiny bits of rubbish and the larger germs are caught in the layers of sand, gravel, stones and tiny water plants. The mineral salts pass through with the water. A filter bed is shown opposite. Can you see how it works?

Finally, a little *chlorine*, which is a poisonous gas, is put into the water to kill any remaining germs. This is called *chlorination*.

Using a filter

Cut out a circle of blotting paper, about 15 cm across. Fold it in the way shown opposite.

Moisten the folded blotting paper and fit it inside a large funnel. Place the funnel in the top of a clean jar.

Stir a little salt and clean sand in water in a jar. What is the colour of the water? Pour the mixture into the funnel.

When all the water has passed through the funnel, look at the blotting paper. What do you notice? Look at the water in the bottle. Is it clear? Taste it. Does it taste salt?

The blotting paper is *porous* and acts as a filter. It contains many tiny holes which you cannot see. The liquid, which is salt *dissolved* in water, can pass through the holes, whereas the sand, which does not dissolve in water, cannot pass through the holes.

This is called *filtering*. The same sort of thing happens in a filter bed.

A model water filter

Make a model water filter in the way shown opposite.

Pour muddy water on to the top tile. What is the purpose of the tiles? Clear water trickles from the hole in the bottom plant pot. Do *not* drink this water for it still contains harmful germs.

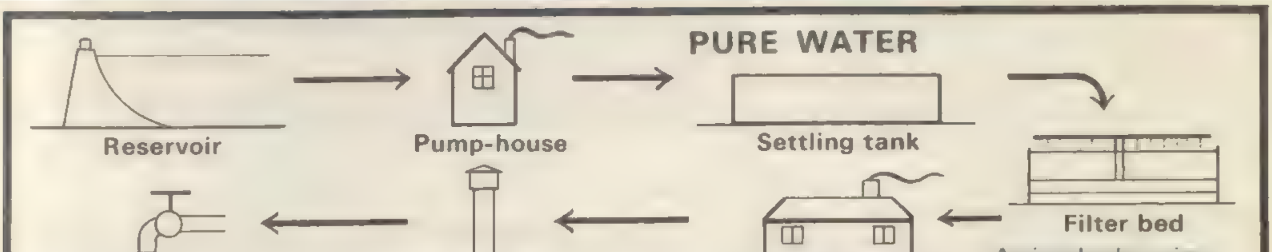
Killing germs by boiling

Country people boil well and spring water to destroy the germs in it and make it fit for drinking.

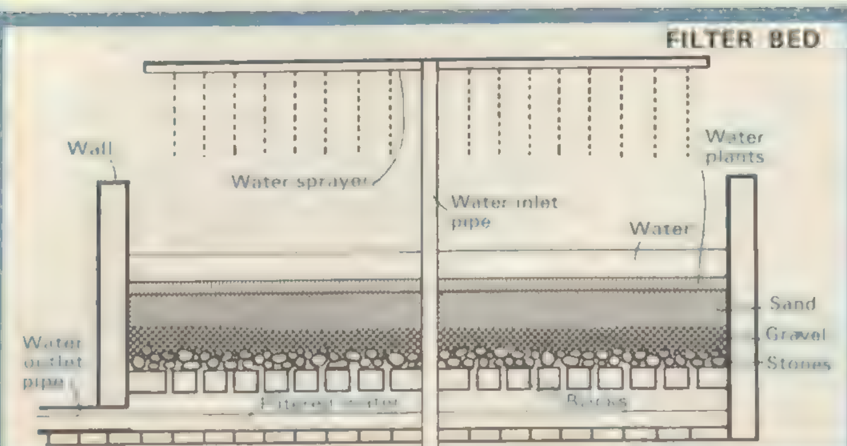
MORE THINGS TO DO

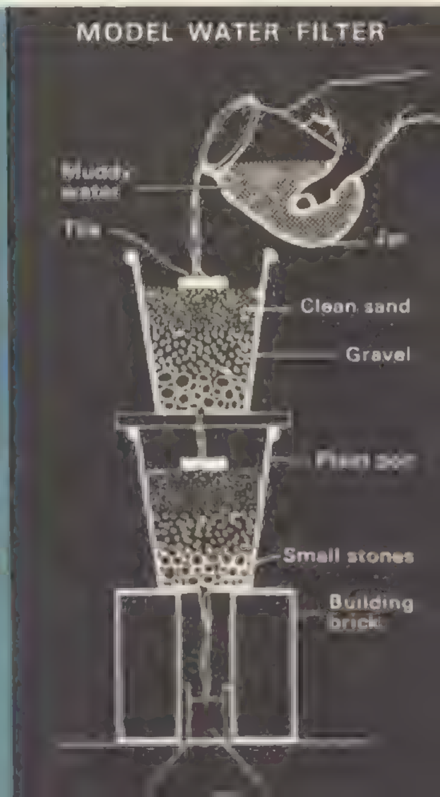
1. Copy the simple "Pure Water" drawing shown opposite.
2. Draw a filter bed. Label each part.

Pure water



A simple drawing for your notebook





4 Water in the home

A house water system

A house water system of a kind in common use is shown opposite.

The black arrows show the direction in which the water flows.

The head of pressure of the water tower forces water out of the wide *main pipe* under the road up through the narrow *service pipe* into the *storage tank* in the roof. The *stopcock*, which is under the pavement and has a metal cover, enables water engineers to turn on or off the water supply to the house.

The *stop tap* is used to turn off the water supply to the whole of the house. This is done when a leak occurs somewhere in the water system, and then the house is not flooded.

The kitchen tap is taken off the service pipe to provide drinking water.

The water level in the storage tank is controlled by a *valve*. When the tank is full, the valve closes and shuts off the water supply. When the water level falls, the valve opens and more water enters the tank from the service pipe. If the valve should fail to work, the tank does not overfill because the unwanted water escapes through the *overflow* pipe. The water in the storage tank is a reserve in case there is a failure in the supply from the main pipe.

The storage tank is at the highest point in the house so that there will be a good head of pressure to make the water flow quickly through the pipes to the taps and *lavatory cistern*.

Taps

Taps are of two kinds – *bib taps* and *stop taps*. Bib taps release water. Stop taps, or *stopcocks*, as they are sometimes called, do not release water but control the flow of water through a water system.

But, both kinds of taps work in the same way. When the handle of a tap is turned in a clockwise direction, a *spindle* rotates downwards and a piece of metal, called a *jumper*, on the end of the spindle presses down into the main chamber of the tap and so shuts off the water. The jumper has a rubber or leather *washer* which acts as a "cushion" and makes certain that no water leaks from the tap.

By the way, the stopcock in the street has no handle and can only be turned on and off with a special tool which is carried by the water engineer.

The parts of a tap

Perhaps your teacher has a spare tap which he will allow you to take to pieces.

Unscrew the *cover*. Use a spanner to unscrew the nut which holds the spindle in place. Take out the spindle and look for the jumper and the washer.

Now, replace the spindle, tighten up the nut, and screw the cover back into position.

Water traps

The U-shaped bends in sink and lavatory waste pipes are called *water traps*. Water collects in the bends and seals off foul gases in the pipes and drains.

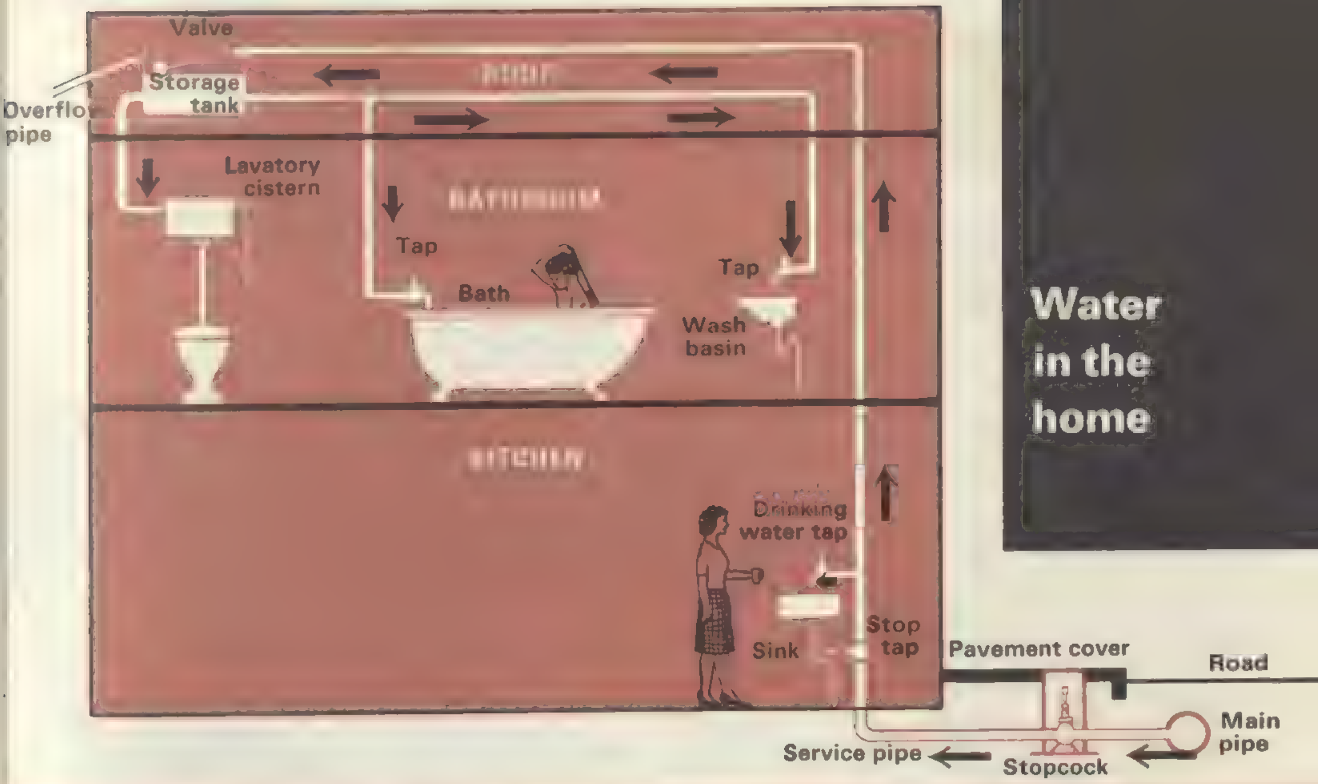
MORE THINGS TO DO

1. Draw a stopcock, a sink trap and a lavatory trap.

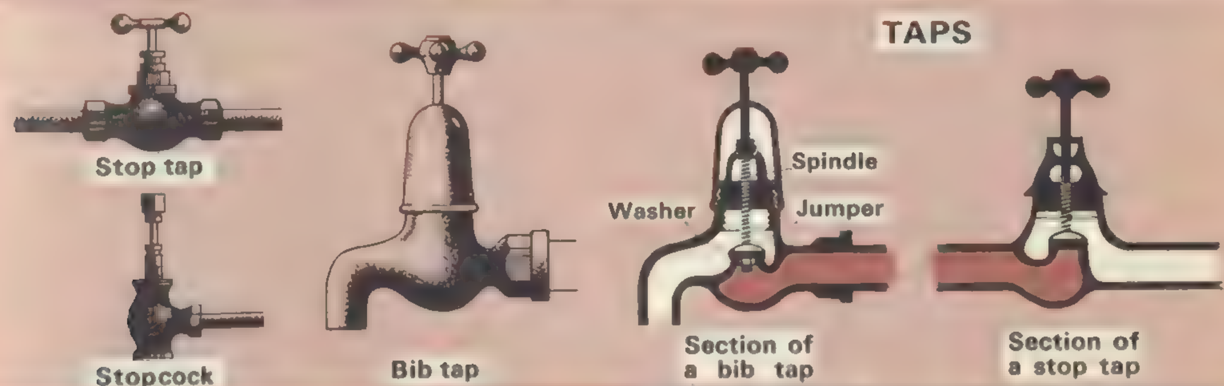
2. With your parents' permission, look for the stop tap in your own house.

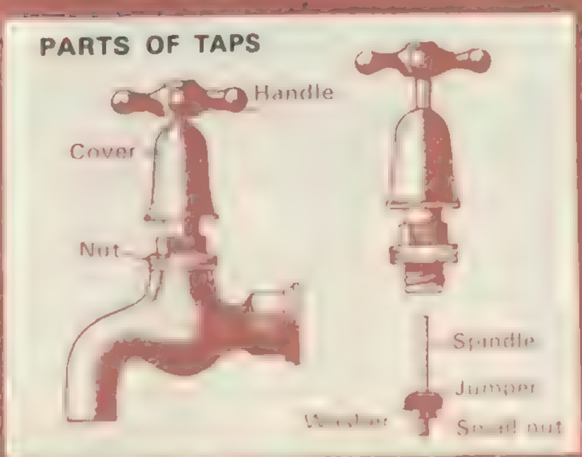
Water in the home

HOUSE WATER SYSTEM



TAPS





5 Hard and soft water

The mineral salts in water

Put a little tap-water in a clean test-tube and heat it until all the water has boiled away. Notice the thin grey-white film of mineral salts around the inside of the tube.

Now, do this with sea-water.

Hard water

Water which contains mineral salts is called *hard water*. It is not easy to make a *lather* with soap and hard water.

What causes the hardness of tap-water? Rain-water soaks into the ground and then flows through soft rock, such as *chalk* and *sandstone*. It dissolves a little of this soft rock and, by the time it reaches the rivers and reservoirs, it contains enough mineral salts to make it hard. Tap-water is not always hard. In districts where the water flows through hard rock, such as *slate* and *granite*, very little rock is dissolved.

Sea-water is very hard because it contains much salt. It is very difficult to make a lather with sea-water.

Soft water

Water which contains little or no mineral salt is called *soft water*. It is easy to make a good lather with soft water.

Rain-water and dew are very soft.

Distilled water is the softest water. It contains no mineral salts and is quite pure. It is used in car batteries.

Making distilled water

Fill a kettle with sea-water or tap-water to which salt has been added.

Boil the kettle and use tongs to hold a large plate over the spout. The steam *condenses* on the surface of the plate. Place a jar below the plate to catch the drops of distilled water.

Taste the distilled water. Does it taste salt or "flat"? What has happened?

Testing for hardness

Shake a few soap shavings and about 0·5 litres of distilled water in a litre bottle to make a soap solution.

Put 5 tablespoonfuls of tap-water in a jar and, stirring with a spoon, pour into it just enough soap solution to make a good lather. Using jars of the same size, do this with sea-water, boiled tap-water, rain-water, river water and distilled water.

Label the jars and arrange them in order according to the amount of soap solution that has been used. Which is the softest water? Which is the hardest?

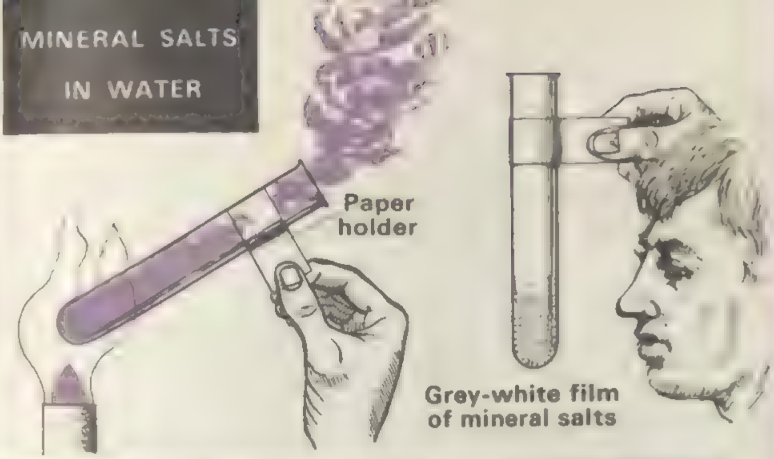
Hard water is a nuisance

The salts in hard water form a "fur" around the insides of kettles, hot-water pipes and steam-engine pipes. In steam engines, this "fur" is called "boiler scale". It is a nuisance because it prevents heat from reaching the water and may cause blocked pipes.

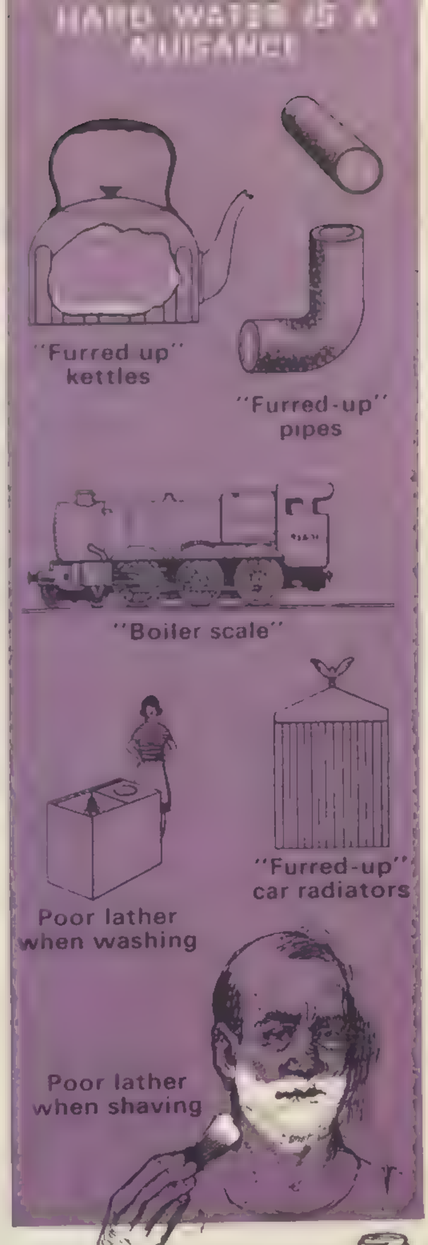
A lot of soap is needed when clothes are washed in hard water. The mineral salts and soap make a scum on the water. Housewives prefer to wash their clothes in rain-water, which is soft.

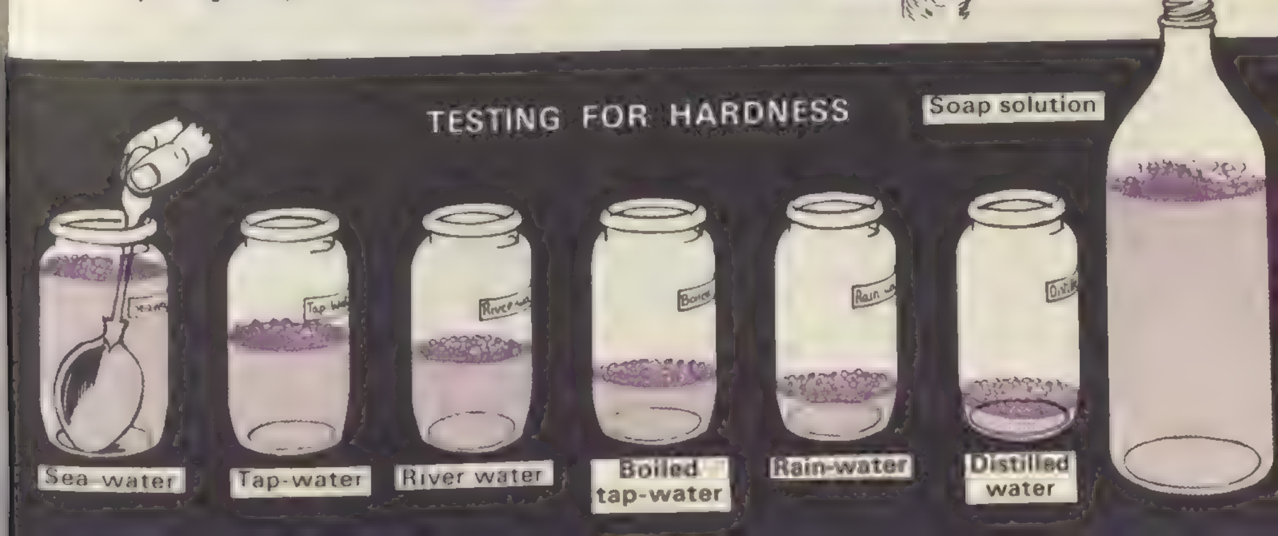
MORE THINGS TO DO

1. Write a few sentences about the hardness of water.
2. Find out why (*a*) a housewife puts a marble in her kettle, and (*b*) a car radiator is sometimes filled with rain-water.



Hard and soft water





6 Washing and cleaning

Health and cleanliness

Grease and dirt carry disease-germs and so, if you want to be healthy, you must do away with grease and dirt by washing your body, wearing clean clothes and keeping your house tidy.

There are four good reasons why you should wash and take baths – to look clean, to smell fresh, to enable you to perspire freely and to destroy disease-germs on your skin. Stale sweat blocks up the pores in your skin and smells quite unpleasant. Have you not heard of *body odour*, or *B.O.*, as it is sometimes called? If you eat with dirty hands, disease-germs may get into your stomach and make you ill.

The "washing-up" should be done with care because stale food and grease on pots, pans and cutlery hold germs and can cause food-poisoning.

Soap and detergents

Soap, *washing soda* and *detergents* are used for removing grease and dirt.

Soap contains dye, perfume, fat and a chemical which, if used alone and without fat, would be harmful to the skin. Soap and hot water break up the grease sticking to surfaces so that it becomes tiny drops of oil floating in water. This is called an *emulsion*. Grease is another name for oil and fat.

Washing soda kills germs and changes grease into an emulsion. Washing soda also softens hard water.

Bath salts are made of washing soda, dye and perfume.

Detergents usually do not contain soap but chemicals which make a lather and soften hard water.

Scouring soap, which is used for removing thick grease, heavy dirt, rust, etc., contains an *abrasive*. An abrasive is a material which can be used for scraping. Chalk and sand are abrasives.

Why do boy scouts use sand for cleaning their pots and pans?

Making an emulsion

Shake water and a little olive oil together in a bottle. Let the bottle stand for a time. You will notice that the mixture separates and the olive oil floats on the surface of the water.

Do this again, but, this time, put a little detergent in the bottle. The mixture does not separate. What have you made?

Using an abrasive

Dab a wet cloth in *powdered chalk* and use it for cleaning sinks, metal taps, etc. The chalk powder scrapes off the grease and dirt.

Softening water

For all washing, it is better to use soft water than hard water because it is easy to make a lather with soft water and less soap or detergent is needed.

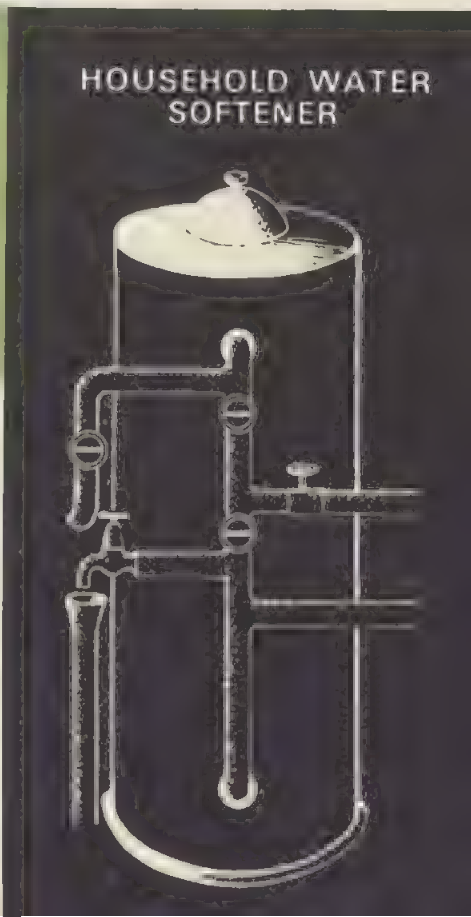
One kind of hard water can be made soft by boiling it. Another kind is made soft by adding washing soda.

A *household water softener* contains special chemicals which change hard water into soft water.

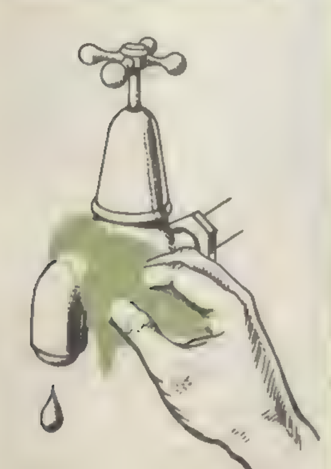
MORE THINGS TO DO

1. Write a short essay with the title *Health and Cleanliness*.
2. With your parents' permission, do the washing-up at home.
3. If you get an opportunity, look at a household water softener and find out how it works.

Washing and cleaning



USING AN ABRASIVE



MAKING AN EMULSION

7 Buoyancy

Floating and sinking

Drop these objects into a bowl of water. Which objects float? Which sink?

Nail; cork; pencil; safety-pin; penny; match; pebble; milk straw.

Push the point of the nail into the cork and drop it into the water. The nail does not sink. Can you explain this?

Place a saucer and a small can, with its lid on, on the surface of the water. Do they float?

Why do things float?

Things float if they are made of materials that are not as heavy as water. Pencils and matches float because wood is not as heavy as water; safety pins and nails sink because iron is heavier than water.

But, a log of wood will float and yet it is heavier than a bucket of water, and so what do we mean by "wood is not as heavy as water"? We mean that wood weighs less than water if they occupy the same amount of space. Suppose that we have three cubes, all the same size, one of wood, one of ice (frozen water) and one of iron. Which is the lightest cube? Which is the heaviest?

Iron ships float

But, what about iron ships? They float even though iron is heavier than water. This is because iron ships, like the saucer and the can in the last experiment, are not solid. Only the outside of a ship is made of iron; the inside is full of air, and air is very light in weight. The iron and air together are not as heavy as the water which would occupy the same space as the ship. If the ship were made of solid iron, it would sink.

Buoyancy

When things float, they are supported by water and seem to have no weight. This support is called *buoyancy*. If a thing is buoyant, it will float.

Showing buoyancy

Hold a large block of wood on the bottom of a bucket of water. Can you feel the block pushing upwards? The water is trying to support the block.

Do the same with a tennis ball, an inflated balloon and a can with its lid on.

Use string to hang a wooden block on the hook of a spring balance. What is the weight of the block? Lower it into the bucket of water. What is the weight of the block now?

Hang a building brick on the hook of the spring balance. What is the weight of the brick? Lower it into the bucket. The brick seems to weigh less. Why?

Using buoyancy

Ships, swimmers, water birds, *water-wings*, *lifebelts* and *buoys* are kept afloat by the buoyancy of water.

Plimsoll lines

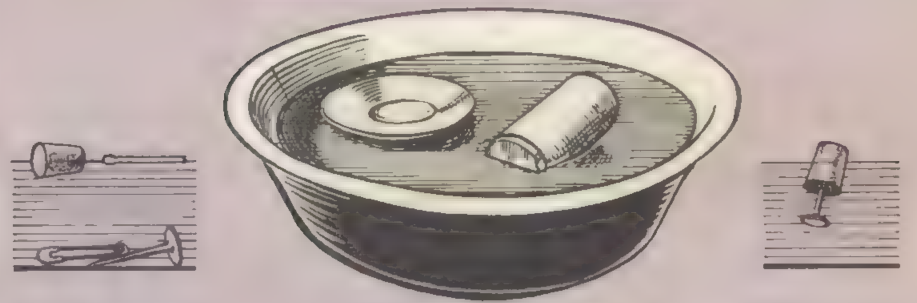
The *Plimsoll lines* on the side of a ship show the depths, in different kinds of water, to which it can sink in safety when it is loaded. Overloaded ships are liable to capsize. These lines are named after Samuel Plimsoll who invented them.

MORE THINGS TO DO

1. Write a few sentences about buoyancy.
2. Make a plasticine "submarine" in the way shown opposite. You can do this at home.

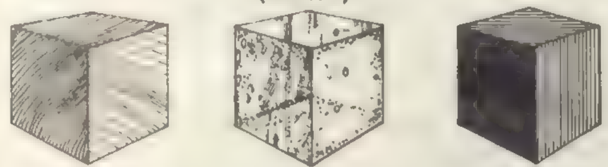
Buoyancy

FLOATING AND SINKING



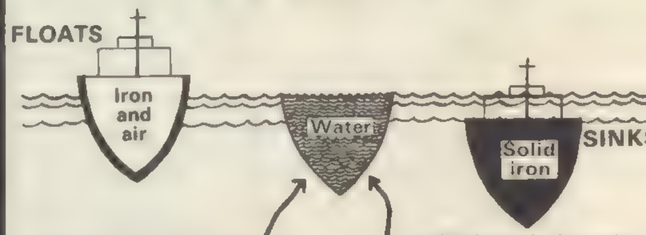
Small objects — Saucer and can — Nail in a cork

WHY THINGS FLOAT

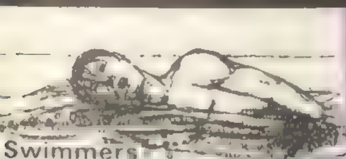


Wood floats and iron sinks

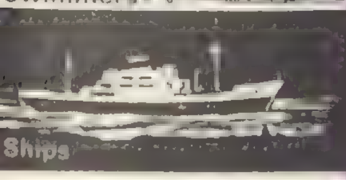
IRON SHIPS FLOAT



USING BUOYANCY

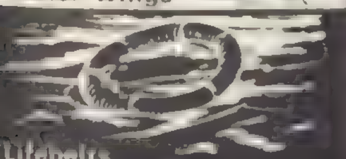


Swimmers



Ships

Water wings

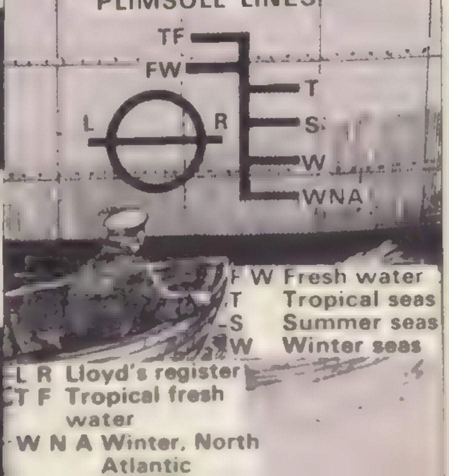


Lifebelts

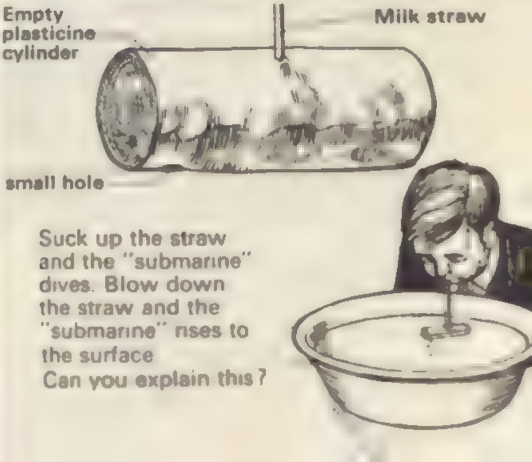
Water birds

SHOWING BUOYANCY

PLIMSOLL LINES



PLASTICINE "SUBMARINE"



Suck up the straw and the "submarine" dives. Blow down the straw and the "submarine" rises to the surface
Can you explain this?

8 Damp courses

Damp walls

What is the cause of damp walls in old houses?

The bricks in houses are *porous* and water from the ground could soak into them and spread upwards to make the walls damp. Builders prevent this by putting in *damp courses*. A damp course is a waterproof layer which is built into a wall just above the ground level. Lead, *asphalt*, slates, *glazed bricks* and *blue bricks* are some of the materials used for making damp courses. Asphalt is a mixture of sand and *pitch*. Pitch is made from *gas-tar*. Glazed bricks and blue bricks are specially made so that their surfaces are smooth and *non-porous*.

But, sometimes, the damp courses in old houses fail to work properly and then the walls become damp.

Building bricks are porous

Use string to hang a dry building brick on the hook of a spring balance. Make a note of the weight of the brick.

Unhook the brick from the balance and stand it upright in a bowl of water. Notice the air bubbles which rise in the water. Where do they come from?

After a few hours, feel the top of the brick. It is wet. What does this show?

Again, hang the brick on the hook of the spring balance. What is the weight of the brick now? Can you work out the weight of the water that the brick contains?

Capillary attraction

When the water in a tumbler is poured away, a thin film of water, attracted by the glass, remains behind. A small drop of water hangs from a tap and does not fall. Water rises in a porous brick because it is attracted by the surfaces inside the holes in the brick. This attraction between water and a surface is called *capillary attraction.*

Have you noticed that the surface of water in a tube is curved downwards? This is caused by capillary attraction between the water and the sides of the tube. The curved surface of water in a tube is called the *meniscus.*

Some capillary attraction experiments

1. Half fill a test-tube with water. Can you see the meniscus?

2. Dip a pencil into water. A few drops of water stick to the pencil.

3. Put a small heap of sugar and a piece of sponge in a saucer of water which has been coloured with a few drops of red ink. Stand a stick of chalk upright in the saucer. Also, place the ends of a strip of white blotting paper, a length of thick string and a piece of cloth in the saucer. Notice what happens.

4. Write on newspaper with a pen and ink. Why does the ink smudge?

Using capillary attraction

Capillary attraction is a nuisance when it causes damp walls, but it is also very helpful. Some of the uses of capillary attraction are shown opposite.

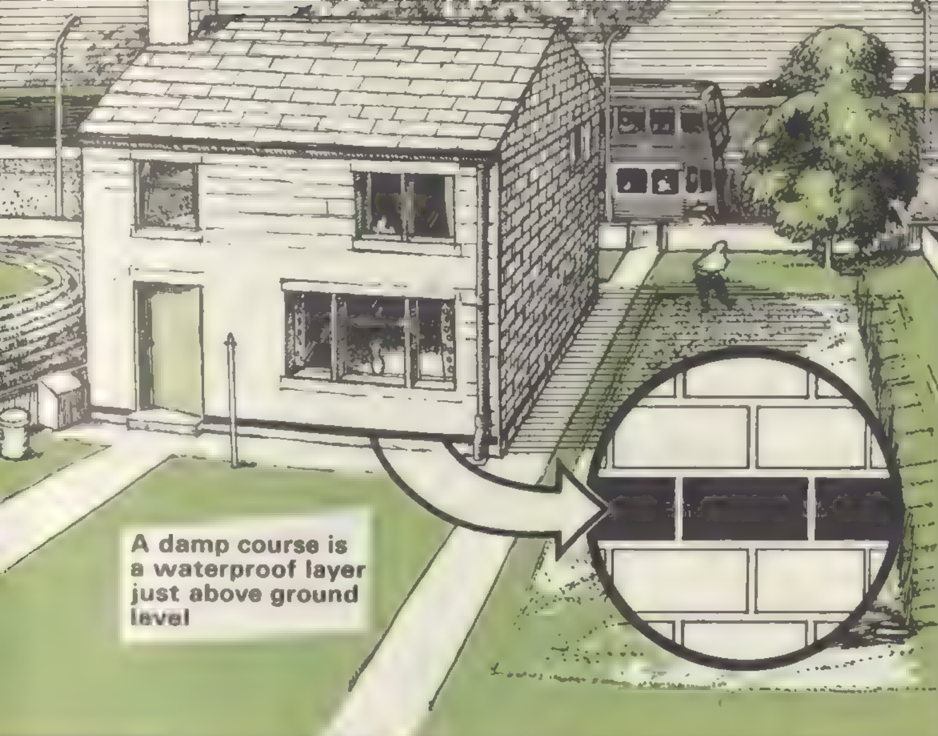
MORE THINGS TO DO

1. Draw a house and mark the position of the damp course with a thick line.

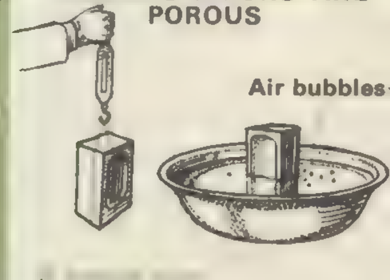
2. Make a list of the uses of capillary attraction.

3. Look for the damp course in your own house.

Damp courses



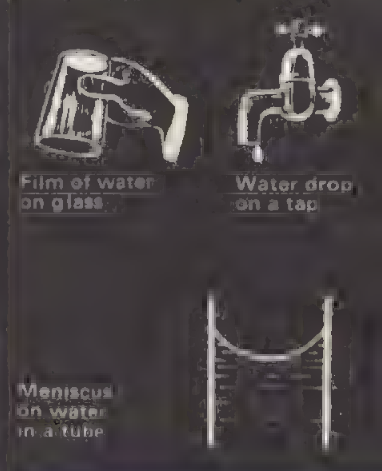
BUILDING BRICKS ARE POROUS



Weight of wet brick = ______
Weight of dry brick = ______
Weight of water = ______

CAPILLARY ATTRACTION EXPERIMENTS

CAPILLARY ATTRACTION



USING CAPILLARY ATTRACTION

9 Growing bulbs

Flowers for the winter

Late autumn, in Britain, is the time when you should plant *bulbs* which are to be grown indoors. They will give you flowers for the winter.

Looking at bulbs

Look at all the different kinds of bulbs that are available – daffodil, tulip, hyacinth, onion, snowdrop, scilla, etc. Notice their shapes, sizes and colours.

Growing bulbs in bowls

This is the way to grow bulbs in bowls.

First, prepare some *fibre*. Notice that it contains sand, *charcoal*, pieces of shell and *peat*. Peat is a kind of moss. Put the fibre in a large bucket and add water to it. Stir the fibre with a stick until all of it is moist.

Then, half fill some bowls with the moist fibre. Place a few of the bulbs, with their pointed ends upwards, in each bowl. Pack fibre around the bulbs until their tips are just showing.

Put the bowls in a cool, dark, airy place, such as a cupboard.

Water the fibre now and again so that it never becomes dry. Do not over-water the fibre; the bulbs will not grow healthily if the fibre becomes too wet. The small pieces of black charcoal in the fibre keep the water fresh so that there is no nasty smell.

Bring the bulbs out into the light when their shoots have grown well above the fibre.

Growing bulbs on jars

Grow a hyacinth bulb or an onion bulb on the top of a jar filled with water. The bulb seals in the water so that it cannot evaporate. This means that the bulb has a water supply which should last for a few months.

Cover the bulb with a paper cone so that it will begin its growth in darkness. Remove the cone when the shoots are about two centimetres long.

Grow a scilla bulb or a tulip bulb on the top of a narrow jar or a medicine bottle.

You will be able to see the roots growing down into the water. The plants live on the food in the bulbs.

What is a bulb?

A bulb contains, tightly packed, all the parts of a flowering plant – roots, a short flat stem, flower shoots and swollen food leaves.

Many of the plants grown from bulbs can also be grown from seeds, but gardeners prefer to use bulbs because the food stored in them gives the young plants a good start in life.

The parts of an onion bulb

Cut an onion bulb in half. Look for the thin, dry, outside leaves, the swollen food leaves, the young shoots, the short flat stem and last year's roots.

MORE THINGS TO DO

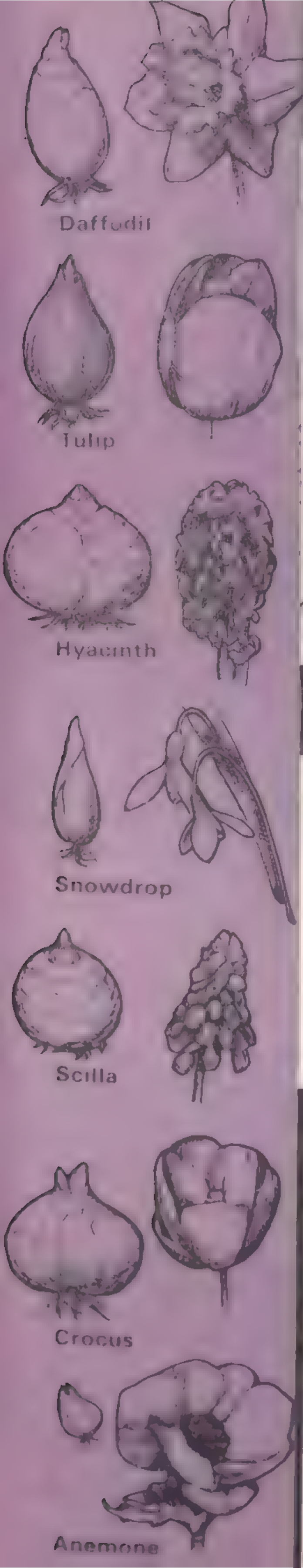
1. Draw a bowl of snowdrops. An easy way to do this is shown opposite. Colour the stems and leaves green and the bowl red.

2. Draw one half of an onion bulb. Label each part.

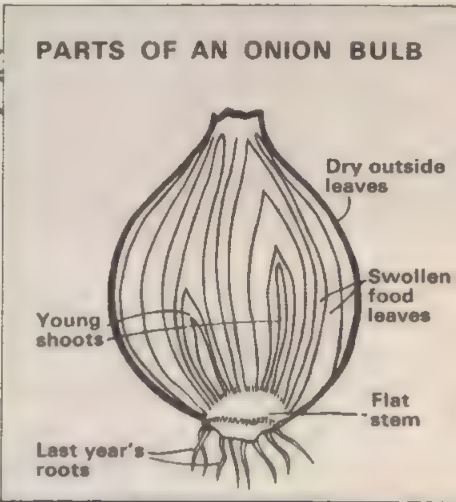
3. Copy these words.

Growing Bulbs

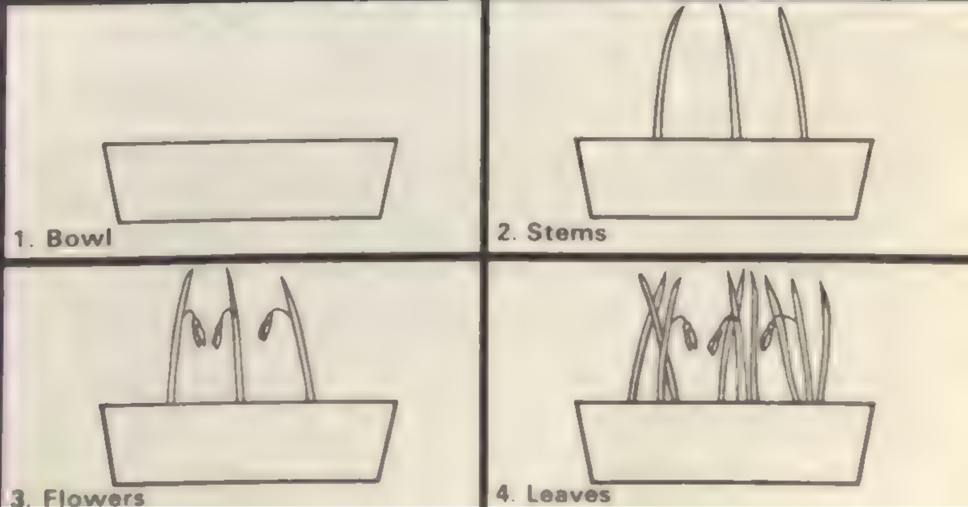
Daffodil; tulip; hyacinth; onion; scilla; snowdrop; crocus; anemone; bulb; fibre; charcoal; peat; moss; sand; shell.



Growing bulbs



DRAWING A BOWL OF SNOWDROPS



10 The potato

The potato: a useful vegetable

The potato is a very useful vegetable. It can be boiled, roasted, baked and fried. There is almost no end to the number of tasty dishes that can be made from the potato.

But, what is the potato? It is a swollen underground stem. It is called a *tuber*.

We know that the potato tuber is a stem because, like the stems which grow above the ground, it has buds and leaves. These buds and leaves are called "*eyes*". Also, when potato tubers grow above the ground in the sunlight, their skins are green as are the skins of other plant stems. Green potato tubers and the green parts of a potato plant are poisonous.

About 1/5 of the potato is *starch*; the rest is water. Starch contains energy. When you eat potatoes, your body takes in starch which gives you the energy you need for work and play.

How the potato grows

Farmers and gardeners grow potato plants from "seed potatoes". "Seed potatoes" are not seeds but tubers which have been kept from the previous year.

The buds in the "eyes" of the potato tuber grow into shoots and roots. The tuber goes soft as the food and water in it is used up by the young plant.

The side shoots at the bottom of the stems grow sidewards and then downwards. The ends of these shoots fill with food and swell to become new tubers. If these tubers were allowed to remain in the ground, they would grow into new potato plants in the following year.

The flowers of the potato plant are white. The fruits look like small green tomatoes. It is very difficult to grow potato plants from seeds.

Sometimes, a gardener cuts his large "seed potatoes" into pieces before he plants them. Each piece will grow if it has an "eye".

A potato tuber

Examine a potato tuber. Look for the "eyes" and the tiny breathing holes.

Testing for starch

Put a little starch powder into a test-tube which is about half full of water. Shake the test-tube and then add to it a few drops of *iodine*. The colour of the starch changes from white to blue-black.

The starch in a potato

Cut a potato in half. Use the end of a pencil to put a few drops of iodine on the flesh of the potato. The colour of the iodine changes from orange-red to blue-black. What does this show?

The water in a potato

Peel a large potato and then weigh it on a kitchen balance.

After a week, weigh the potato again. How much water has it lost?

What is the purpose of the skin on the potato?

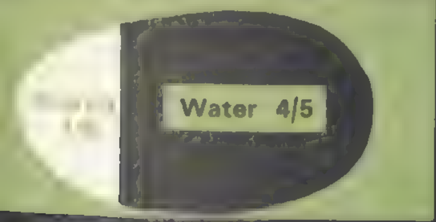
MORE THINGS TO DO

1. Draw a potato tuber. Label it.
2. Write a few sentences about the potato.
3. Grow potatoes in the ways shown opposite.
4. Make some *potato prints* in the way shown opposite.

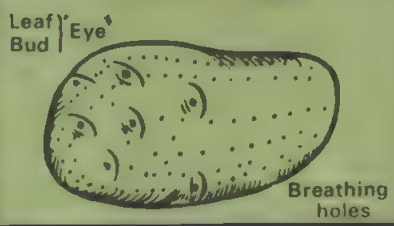
The potato

HOW THE POTATO GROWS

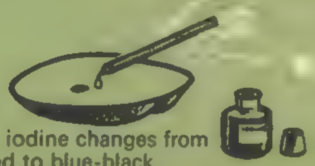
WHAT THE POTATO CONTAINS



POTATO TUBER



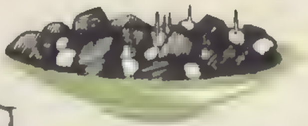
STARCH IN A POTATO



Colour of iodine changes from orange-red to blue-black

GROWING POTATOES



1. Grow a potato on a jar of water. Cut a piece off the smooth end of the potato. Cover the potato with a paper cone so that it begins its growth in darkness.

2. Plant a small potato in soil, fibre or sawdust in a biscuit tin. Keep the soil moist, but not too moist. The potato plant may give you new little tubers.

3. Cut a potato into pieces. Make sure that each piece has at least one "eye". Plant the pieces in soil, fibre or sawdust in a biscuit tin. Each piece should grow.

4. Place pieces of potato – some with "eyes" and some without – in a saucer of water. Cover them with small stones. Do the "eyeless" pieces grow?

POTATO PRINTS




1. Cut pieces out of the end of a potato to make a shape.

2. Cut off the end of the potato to make a flat surface for printing.

3. Press the flat surface on a cotton-wool pad soaked in ink.

4. Press the inked surface on the edge of a sheet of paper. Do this several times to make a border pattern.

11 Food for the birds

Feeding the birds

Birds are lively creatures and so they want plenty of food. The food they eat contains the energy they need to keep them active. In winter, when it is cold, they want extra food to give them the energy they need to keep warm.

In winter-time, you should help the birds by feeding them. They do not find many seeds and berries during the winter months, and they cannot get at the insects, grubs and worms in the hard frozen ground; and so they will welcome any odd scraps of food that you put out for them.

If you put the food scraps on a *bird-table*, you will be able to watch the birds which visit it.

Making a bird-table

Here is an easy way to make a bird-table. You could make one at home.

Nail a few large twigs on the top of a wooden board, about 30 centimetres square. The birds will be able to perch on these. Then, knock a nail in each of the four corners. Tie the ends of four strings to these nails. Then, tie the other ends of the strings together.

Hang up the table somewhere outside well out of reach of cats.

Put food on the table. This can include hips and haws, privet, ivy and yew berries, cheese and bacon rinds, fatty meat, suet, boiled potato, bread-crumbs, biscuits, porridge oats, hemp seeds and other small seeds.

Use a large needle to thread thin string through some peanuts. Hang up the string of peanuts and a half of a coconut for the tits.

Remove the stale food and the bird droppings each day. Clean the table every week.

Place a dish of water on or near the table. Fill up the dish every day. This water will be very helpful to the birds in the cold weather when the ponds are covered in ice.

Watching the birds

If you stand close to the table, the birds will not come to it. They will be afraid of you. But, if you hang the table near to the window of a building, you will be able to watch the birds fairly closely from inside. They will not see you.

When you are watching birds, you should notice their sizes, shapes and colours, their songs, the kinds of food they eat, how they fly and whether they walk or hop. A picture-book of birds will help you to find out their names.

Some common birds

Some common birds are shown opposite. All these birds will not visit the bird-table. The birds shown are all the same size, but, in real life, some are bigger than others. A blackbird, for example, is much bigger than a wren.

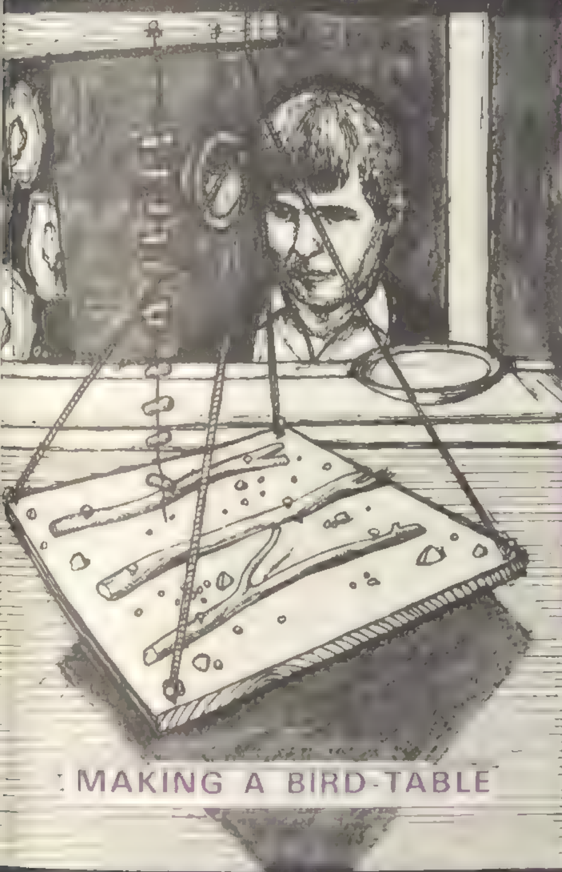
Beaks and feet

The beaks and feet of birds show how they feed and move. Some beaks and feet of birds are shown opposite.

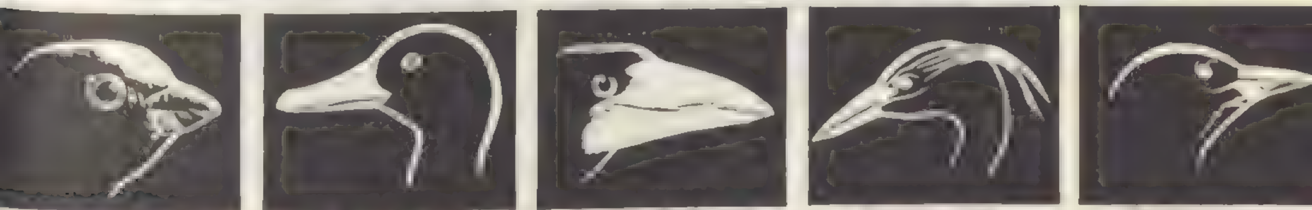
MORE THINGS TO DO

1. Find pictures of birds in old magazines, comics, etc. Cut out a few of them and paste them into your notebook.
2. Make a list of 10 common birds.
3. If you do make a bird-table at home, then tell your teacher of any unusual birds that visit it.

Food for the birds



BEAKS AND FEET



Cracking seeds	[illegible] and shovelling mud	[illegible] and digging for worms	Catching fish	Catching insects
Sparrow	**Duck**	**Rook**	**Heron**	**Starling**

Perch[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pigeon	**Eagle**	**Woodpecker**	**Sea-gull**	**Fowl**

12 Keeping warm

Keeping warm in winter

When the cold weather of winter comes, men and animals keep warm by wearing extra clothing, eating more food and staying inside their homes.

Food and warmth

The food eaten by animals contains the energy they need to keep them warm.

Birds are always on the move. They must have plenty of food to keep them warm and active. But, food is scarce in winter and many birds die during very cold spells because of lack of food.

Clothing

Some animals keep warm in winter by growing extra "clothing". Rabbits and hares grow thick coats of fur, dogs and horses grow thick coats of hair, and sheep grow thick coats of wool. Birds fluff out their feathers when it is cold.

Some of our winter clothing is made of sheep's wool and animal furs. In cold weather, we wear fur gloves, woollen scarves and thick woollen overcoats. *Eskimoes*, who live in a very cold land, wear thick fur-lined garments.

We speak, quite wrongly, of "keeping out the cold". Really, we wear clothing to keep in the heat of our bodies.

Warm and cool clothing

Touch a bundle of feathers, your hair and pieces of clothing made of fur, wool, cotton, linen and silk. Which of these things feel warm?

Shelter

Horses and cattle stand in sheltered places when the weather is cold. Sheep huddle together to shelter each other when a cold wind is blowing. If it is very cold, farmers put their horses in stables and their cattle in cowsheds.

Some animals take shelter in their homes during the winter and come out only for food and exercise. Rabbits live in deep burrows; they must be quite warm. The fox often makes himself a cosy home in a rabbit burrow.

We live in heated houses built of wood, brick, stone and concrete. An Eskimo's home, which is called an *igloo*, is made of blocks of solid snow.

The winter sleep of animals

In autumn, when the weather becomes colder, many animals find safe places where they can sleep through the winter. They do not feel the cold and they live on the fat stored in their bodies. They will not wake up until the spring. This winter sleep of animals is called *hibernation*.

Some hibernating animals are shown opposite.

The squirrel sleeps in an old rook's nest or a hole in a tree. Bats sleep, hanging upside down by their feet, in caves and barns. Insects hibernate in small holes in buildings and the ground. Frogs and fishes lie in the mud at the bottom of lakes, ponds and rivers.

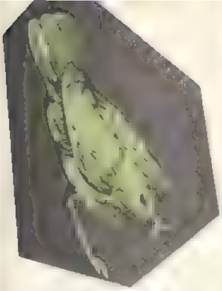
MORE THINGS TO DO

1. Draw a tortoise. An easy way to do this is shown opposite. Colour it brown.
2. Make a list of 10 hibernating animals.
3. Copy this sentence.

Keeping Warm

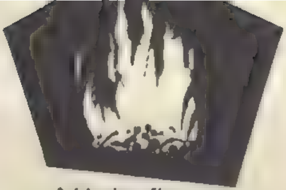
Men and animals keep warm in winter by eating more food, wearing extra clothing and staying inside their shelters.

Keeping warm



Birds eat plenty of food

Sheep huddling together in a cold wind



A blazing fire

A bird fluffing out his feathers

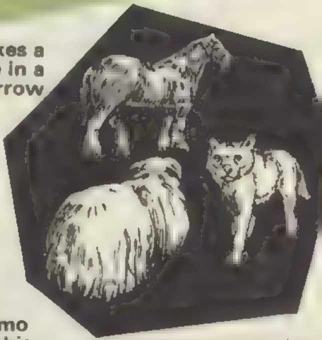
Houses

The fox makes a cosy house in a rabbit burrow

A squirrel asleep inside a tree trunk

Thick clothing of wool and fur

An Eskimo outside his igloo



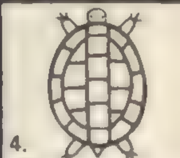
Animal "clothing" of fur hair and wool

SOME ANIMALS WHICH HIBERNATE

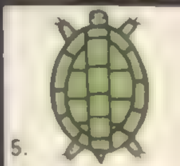
1. Shell

2. Legs

3. Head and ta



4. Shell marking



5. Colour brown

13 Heat insulators

Things feel cold and warm

Touch these things with your fingers. Which feel cold? Which feel warm?

Sink tap; carpet; scarf; cork; sheet of paper; knife blade; eraser; feather; water pipe; scissors; piece of wood.

Conductors and insulators

The things you have just touched are all at the same temperature but some feel cold and some feel warm. Why?

The things that feel cool are made of metal. They carry heat well. When you touch them, they quickly carry heat away from your fingers and so your fingers become cool. Really, it is your fingers that are cool and not the things that they touch.

Materials that carry heat well are called *heat conductors*. Metals – iron, copper, etc. – are heat conductors.

The things that feel warm are made of materials that do not carry heat well. When you touch them, they do not allow heat to escape from your fingers and so your fingers remain warm.

Materials that do not carry heat well are called *heat insulators*. Some heat insulators are shown opposite.

Wood is a heat insulator

Strike a match. Hold in its flame a thick copper wire of the same length as the match. Which is dropped first – the match or the copper wire?

Stand a wooden spoon and a metal spoon in a can of hot water. After a minute, feel the handles of the spoons. Which is the warmer handle – the wooden one or the metal one?

What do these two experiments show?

Using heat insulators

Now you understand why a person wears thick clothing in winter. The clothing is a heat insulator; it prevents the escape of heat from his body and so he keeps warm.

Some of the many uses of heat insulators are shown opposite.

Air is a good heat insulator

Air is a good heat insulator. The feathers of birds are good heat insulators because among them there are many spaces which are full of air. In cold weather, birds fluff out their feathers to make more air spaces. Blankets and the hair on your head contain air spaces.

Country people sometimes keep food hot for a number of hours by placing it inside a box of hay. The many air spaces in the hay are heat insulators and heat cannot escape from the food.

Making a hay-box

Fill a large cardboard box with chopped hay. Place a cup of hot water, covered with a saucer, in the middle of the hay. After a few hours, feel the water. Is it still hot?

Potato clamps

During the winter, farmers store their potatoes in *clamps*. A potato clamp is shown opposite. How does the clamp protect the potatoes from frost?

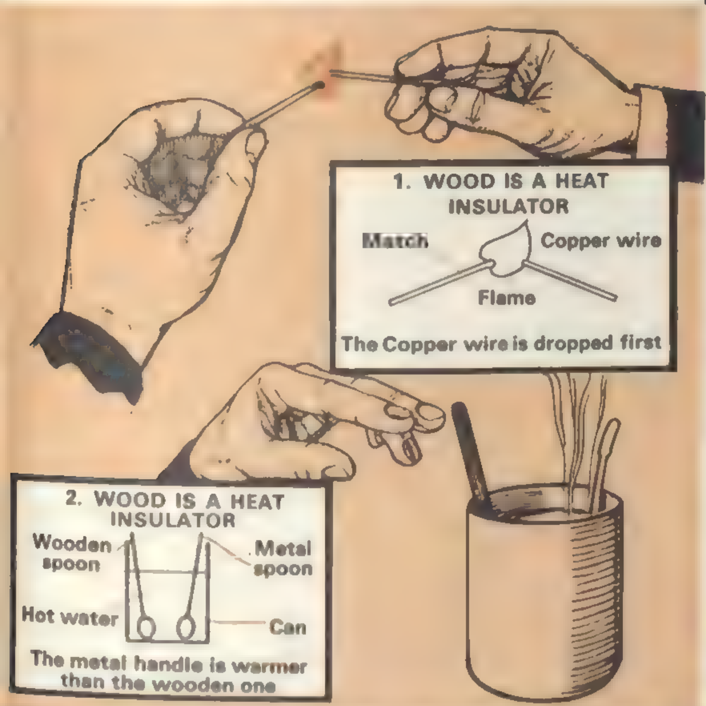
MORE THINGS TO DO

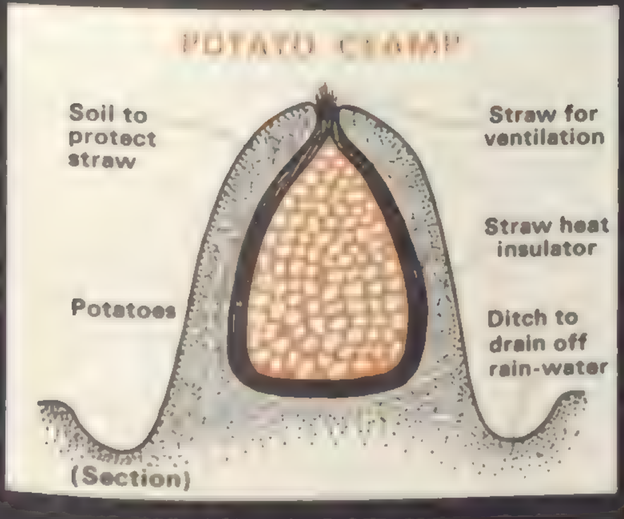
1. Copy the drawings shown in the black frames opposite.
2. Draw a potato clamp.
3. Make a list of 10 heat insulators.
4. Make a list of 15 uses of heat insulators.

Heat insulators

There are many other heat insulators

WOOD IS A HEAT INSULATOR





USING HEAT INSULATORS

MAKING A HAY-BOX

14 How heat travels

Heat travels in three ways

Heat travels in three ways – by *conduction, convection* and *radiation*.

Heat travels through solid things by conduction. If you put the tip of a poker into a fire and allow it to remain there for a few minutes, the handle will become quite warm. This is because heat is conducted through the poker from one part to the next in much the same way that a ball is passed from hand to hand along a line of rugby football players.

Heat travels in liquids and gases by convection. When water is heated, the warm water rises and the cold water falls. This happens because cold water is heavier than warm water. The movements in the heated water are called *convection currents*. Convection can be likened to a rugby football player running with a ball.

Heat travels through space by radiation. The heat radiated by the sun travels across 150 000 megametres of empty space before it reaches the earth. Radiation can be likened to a rugby football player kicking a ball.

Conductors

Metals are good heat conductors; non-metals, like wood and rubber, are poor heat conductors. Of course, poor heat conductors are good heat insulators. Why do metal objects feel colder than objects which are not made of metal? The metal objects, being good heat conductors, carry heat away from your fingers very quickly and your fingers become cool.

Liquids and gases are poor heat conductors. Mercury, which is a liquid metal, is an exception. It is a good heat conductor.

Some conduction experiments

1. Hold one end of a metal knitting needle with your fingers and heat the other end. After a few seconds, you have to drop the knitting needle. Why?
2. Place a penny on a small sheet of white paper. Move the paper about just above a flame until it is scorched all over. Look at the paper. Which part of the paper is scorched least? Can you see the shape of the penny? What has happened?
3. Lay the ends of equal lengths of thick copper and iron wire across a wax candle. Heat the other ends of the wires. Where does the wax melt first – near the end of the copper wire or the iron wire? Which metal is the better conductor?

Water is a poor heat conductor

Fill a test-tube with water and heat the top. After a short time, the water at the top of the test-tube boils. Feel the bottom of the test-tube. Is it still cool? What does this show?

MORE THINGS TO DO

1. Copy the drawing shown in the black frame opposite.
2. Copy these sentences, filling each space with a suitable word.

Conduction

Heat travels in three ways – by conduction, ... and radiation.

Metals are .... heat conductors.

Copper, iron, lead, mercury, tin, silver, gold, aluminium and zinc are ....

Non-metals, liquids and gases are good .... insulators.

Mercury is a .... heat conductor.

How heat travels

CONDUCTION

In solids

The "heat ball" is passed from hand to hand along a line of players

CONVECTION

In liquids and gases

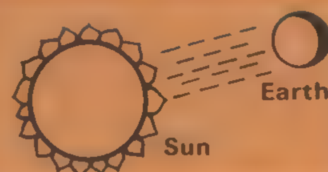
A player runs with the "heat ball"

RADIATION

In space

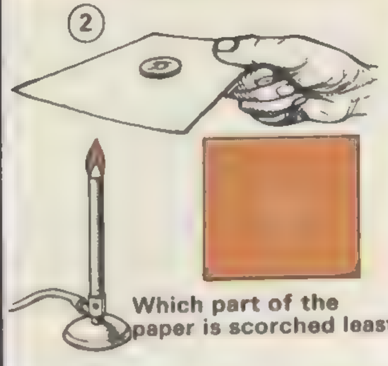
A player kicks the "heat ball"

Heat travels in three ways

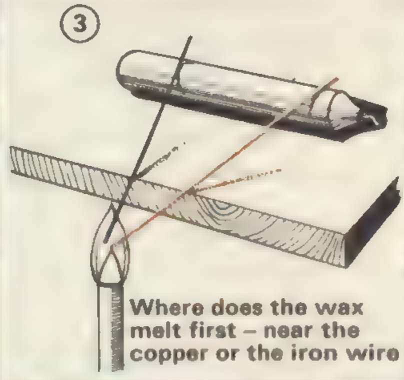


SOME CONDUCTION EXPERIMENTS

Why do you drop the knitting needle?



Which part of the paper is scorched least?

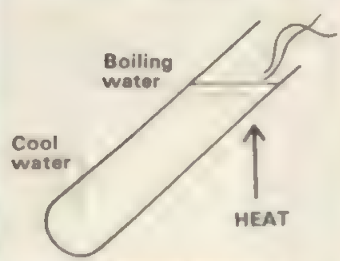


Where does the wax melt first – near the copper or the iron wire?

WATER IS A POOR HEAT CONDUCTOR

The water at the bottom of the test-tube remains cool

WATER IS A POOR HEAT CONDUCTOR



COMMON METALS

Aluminium
Copper
Gold
Iron
Lead
Mercury
Silver
Tin
Zinc

15 Using heat conductors

The uses of heat conductors

Heat conductors have a number of everyday uses.

The bit of a soldering iron is made of *copper* so that it will conduct and hold a lot of heat. Copper is a very good heat conductor.

Kettles, saucepans, frying pans and meat dishes are made of either *aluminium* or *iron*. They heat up very quickly because these metals are good heat conductors.

The *boiler* and *fire-tubes* of a steam-engine are made of copper. The copper conducts heat quickly and easily from the fire into the water.

An *air-cooled petrol engine*, such as a motor-cycle engine, has iron *cooling fins*. They conduct heat away from the engine into the air. This prevents the engine from becoming too hot.

A radiator is made of iron to conduct heat from its inside to its outside.

A spoon in a glass may prevent the glass from cracking when hot water is put into it. The spoon conducts some of the heat away from the water into the air.

The miner's safety lamp

In the eighteenth century, coal-mines were lit with oil lamps and candles. This was risky because the mines often contained explosive gases which were easily ignited by the naked flames. Many fires and explosions were caused by the use of this kind of lighting.

Sir Humphrey Davy overcame the danger of gas explosions in mines when he invented the *miner's safety lamp*. Sometimes, it is called the *Davy lamp*, after its inventor.

The flame of the safety lamp is covered by a wire gauze through which air reaches the flame. The heat from the flame is conducted away by the gauze and, as a result, the explosive gases outside the gauze do not become hot enough to ignite.

Nowadays, mines are lit with electric lamps.

How the miner's safety lamp works

1. Use tongs to hold a wire gauze over the flame of a bunsen burner. The flame does not pass through the gauze. Why?

2. Hold a wire gauze over a bunsen burner. Turn on the gas and ignite the gas above the gauze. The gas below the gauze does not ignite. Why?

3. Make a coil by wrapping thick copper wire around a pencil. Bring the coil down over a candle flame. The flame becomes smaller or is extinguished because its heat is quickly conducted away by the copper wire.

Looking at heat conductors in use

If you get an opportunity, look at the bit of a soldering iron, the fins on a motor-cycle engine and the gauze of a Davy lamp.

MORE THINGS TO DO

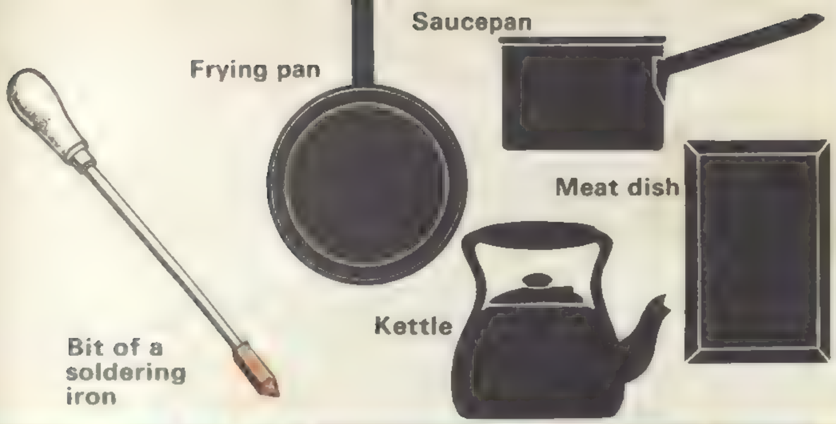
1. Draw the miner's safety lamp.
2. Copy these words.

Using Heat Conductors

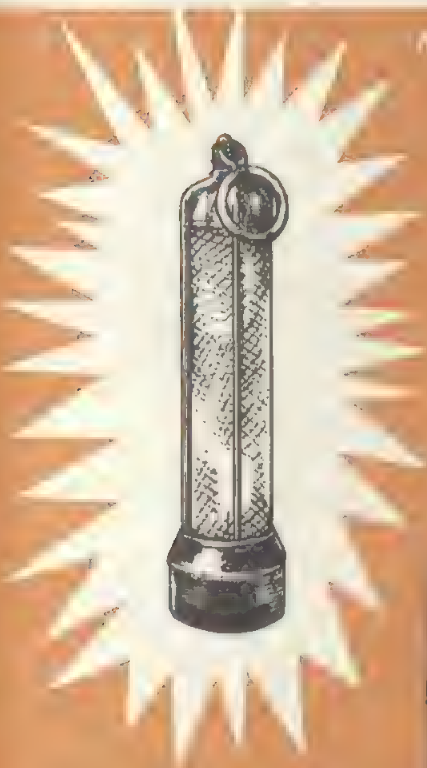
Soldering iron; kettle; saucepan; frying pan; boiler; fire-tubes; fins of an air-cooled engine; radiator; spoon in a glass.

3. Write a few sentences to describe *one* experiment to show how the miner's safety lamp works.

Using heat conductors

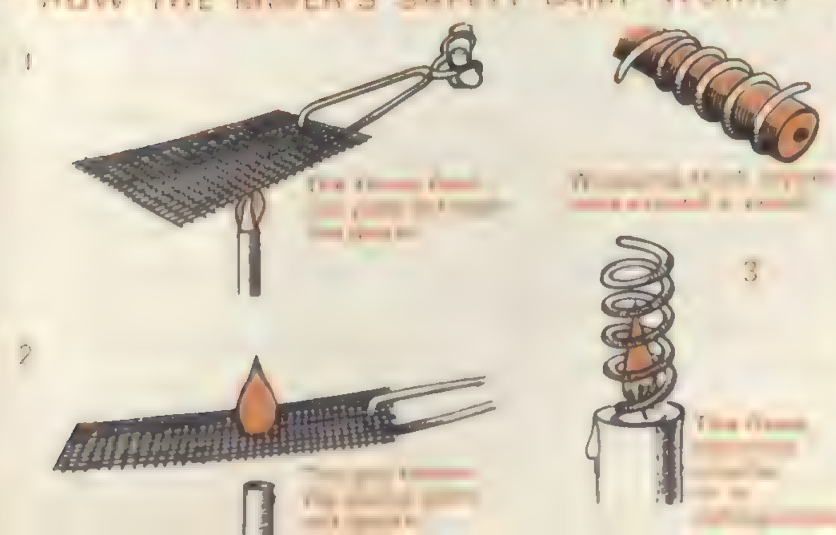


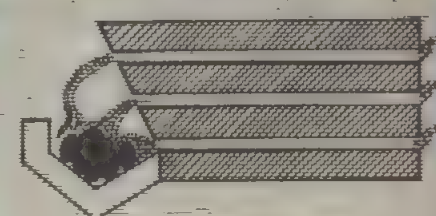
MINER'S SAFETY LAMP



Sir Humphrey Davy, the inventor of the miner's safety lamp

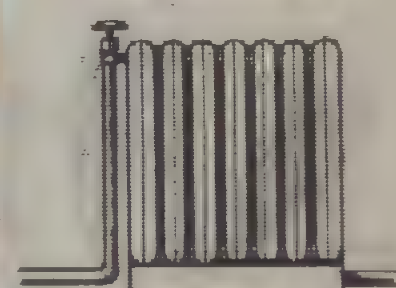
HOW THE MINER'S SAFETY LAMP WORKS





Steam-engine boiler and fire-tubes

Fins on an air-cooled engine



Radiator

Spoon in a glass

16 Nature's blanket

A white blanket of snow

You must have looked out of your bedroom window on some winter morning and been surprised to find that, during the night, Nature had covered the ground with a white blanket of snow.

What is snow? From where does it come? The clouds in the sky are made of tiny drops of water. When clouds meet very cold air, as they often do in winter-time, the drops of water freeze to form tiny crystals of ice which stick together and then fall gently to the ground as *snowflakes*.

Looking at snowflakes

After the next fall of snow, collect a few snowflakes and place them on a sheet of black paper. Quickly, before they melt, look at the snowflakes through a magnifying glass. You will see beautiful and delicate shapes made of tiny, glistening crystals of ice.

Snow is a heat insulator

Snow feels cold to your hands and so, perhaps, you will be rather astonished to learn that it is a warm blanket for the ground.

Snow is a good heat insulator because it contains many air spaces. The air spaces in snow do not allow what little warmth there is in the ground to escape into the cold air above it. The tender plants, seeds and bulbs under the snow are not killed by the severe cold.

The air spaces in snow

Fill a jar with snow and stand it near a radiator. The snow melts, but the water formed does not fill the jar. Why?

Icicles

When the weather becomes warmer, snow and ice melt. We say that they *thaw*. If the weather becomes cold again, the water dripping from roofs and trees re-freezes to form long spikes of ice which are called *icicles*.

Footprints in the snow

Many wild animals stay in their homes during the winter, but some, like the rabbit and the hare, do not seem to mind the cold weather. Perhaps you have seen their footprints in the snow.

Do not be deceived by the track of a rabbit or a hare. When a rabbit or a hare is running, it places its large hind feet in front of its little fore feet, and so its track makes you think that it was travelling in the direction opposite to its real direction.

The track of a fox is a zigzag line of footprints because it puts its hind feet in the holes left by its fore feet.

The footprints of a sparrow are in pairs because this bird hops along. The footprints of a starling are in a single line because this bird walks, putting one foot in front of the other.

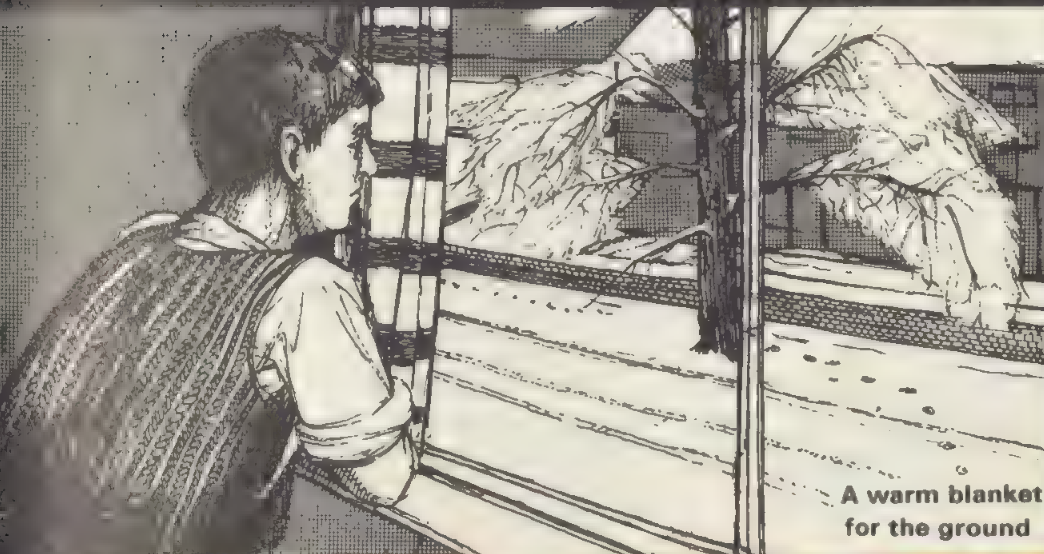
A deer's footprint is in two parts for this animal has split, or *cloven*, hooves.

MORE THINGS TO DO

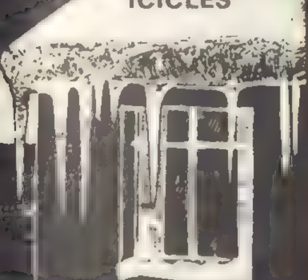
1. Make a snowstorm scene for your notebook in the way shown opposite.
2. Draw a snowflake. Use a white crayon and black paper. Paste the drawing into your notebook.
3. Draw some animal footprints. Label each drawing.
4. Write a short essay with the title *Nature's Blanket*.

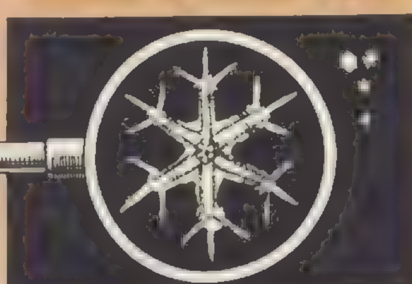
SNOWFLAKES Notice their beautiful shapes

Nature's blanket



ICICLES



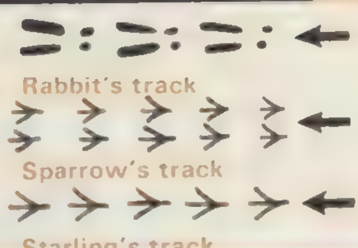


1. Jar full of snow

2. After the snow has melted

FOOTPRINTS IN THE SNOW

The fox's track is a zigzag line of footprints

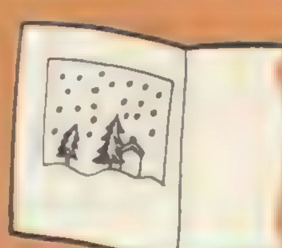


MAKING A SNOWSTORM SCENE

1. Cut the bottom edge of a sheet of blue paper so that it is wavy

2. Draw fir trees, a house, etc.

3. Use a small nail to punch many small holes



4. Paste the paper into your notebook

17 Frozen pipes

Burst water pipes

Why are there so many burst water pipes during a spell of very cold weather? When the water in a pipe freezes, it expands and, in so doing, it may burst the pipe. The burst pipe is not noticed until the thaw; the water then leaks from the cracks in the pipe.

Pipe bursts usually occur where pipes are fixed to outside walls or are exposed to draughts, as they are in roofs and near ventilators.

Freezing water expands

Find a small bottle with a screw cap and fill it with water. Screw on the cap and place it in a bowl which contains a *freezing mixture*. Cover the bowl with a cloth as a protection against flying splinters of glass. If the weather is very cold, there is no need to use a freezing mixture; simply leave the bottle outside.

A freezing mixture contains 2 parts of crushed ice and 1 part of table salt. Its temperature is lower than 0°C, the temperature at which water freezes.

After a few hours, you will find that the water in the bottle has changed into ice and the bottle has burst. What has caused the bottle to burst?

Preventing burst pipes

Pipes that are liable to freeze up are sometimes *lagged* with rags, sacking, etc. This *lagging* is a heat insulator and prevents heat from leaving the pipes. Even cold water contains a little heat.

When it is very cold, the cold draughts which may cause frozen pipes can be prevented by keeping ventilators, doors and windows closed.

An electric heater or an oil lamp in an outside toilet prevents frozen pipes.

What to do with a burst pipe

This is what to do with a burst pipe.

1. Plug the holes with a rag and wrap it tightly around the pipe.
2. Place a bucket under the leak.
3. Turn on the taps.
4. Mop up the water.
5. Fetch the plumber.

Weathering by ice

Water collects in the cracks in rocks. When the water freezes, it expands and breaks up the rocks. This is called *weathering by ice*.

Ice floats

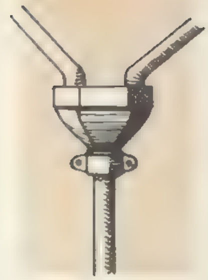
Below 4°C, water behaves in a strange sort of way. When it is cooled, it does not contract but expands. Water expands when it freezes. When water changes into ice, its volume increases by 0·1. Ice, then, is not as heavy as water. That is why *icebergs* float.

Ponds do not freeze up during the winter unless the cold is very severe. The cold water on the surface of a pond floats because it is not quite as heavy as the slightly warmer water at the bottom of the pond. Ice forms on the surface and not on the bottom of the pond. During a cold spell, fish and other water animals retreat to the slightly warmer depths of the pond.

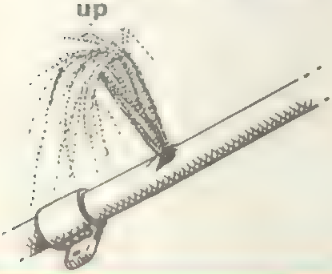
MORE THINGS TO DO

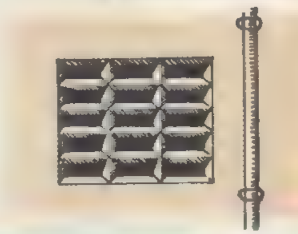
1. Copy the drawing shown in the black frame opposite.
2. Draw a lagged pipe.
3. Copy the section about what to do with a burst pipe.

Frozen pipes

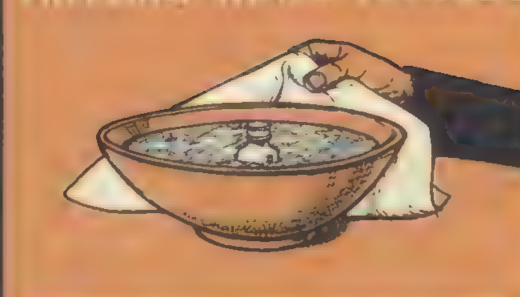


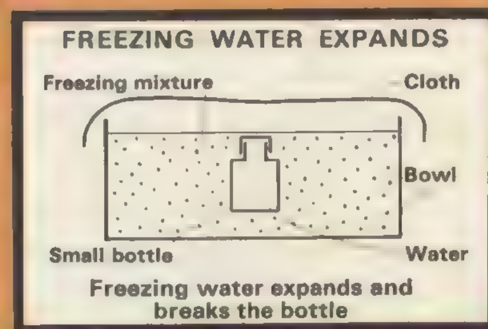
Outside pipes and pipes near ventilators are liable to freeze up





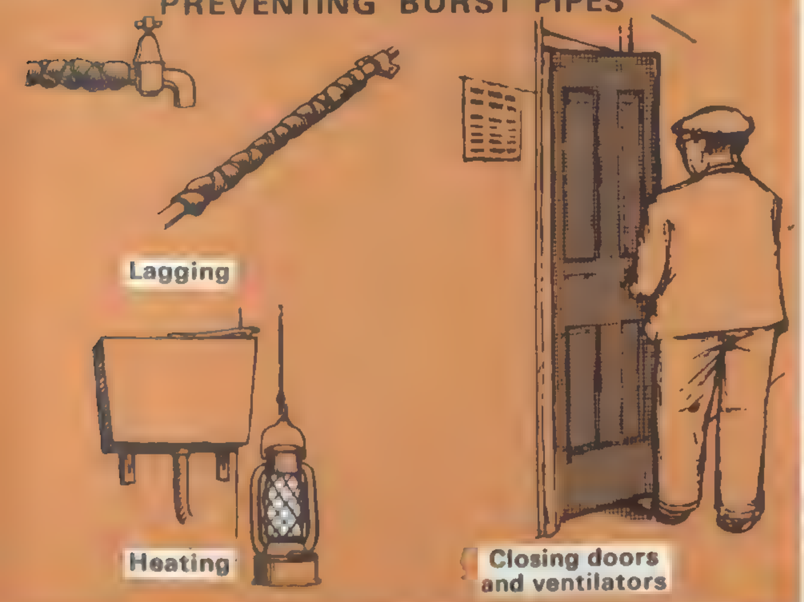
FREEZING WATER EXPANDS



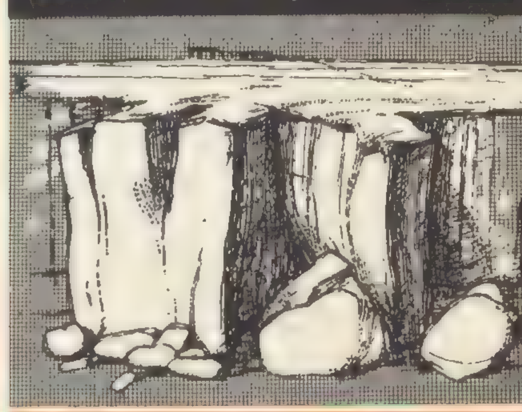


Freezing water expands and breaks the bottle

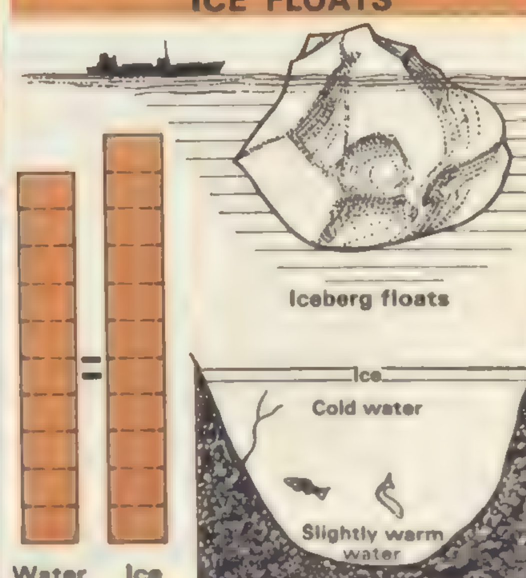
PREVENTING BURST PIPES



WEATHERING BY ICE

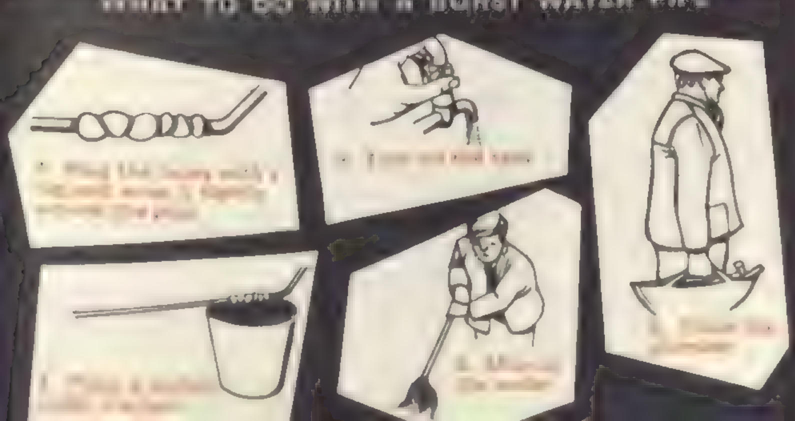


ICE FLOATS



Pond does not freeze solid

WHAT TO DO WITH A BURST WATER PIPE



18 Convection currents

How heat travels in liquids and gases

What does a cork do if you hold it at the bottom of a bucket of water and then let it go? Of course, it rises to the surface of the water and floats. This is because cork is lighter in weight than water.

The same sort of thing happens when a liquid or a gas is heated. The warm fluid is lighter in weight than the cold fluid. The warm fluid rises and the cold fluid falls. This makes the convection currents by which heat travels through a liquid or a gas.

Ocean currents

Ocean currents are convection currents. Heat from the sun warms the water on the surface of the ocean. The water expands and spreads outwards. Its place is taken by cold water from below the surface.

Some convection experiments

1. Put a few *potassium permanganate* crystals at the bottom of a large, glass, oven dish. Your teacher will supply you with these crystals. Fill the dish gently with water so as not to disturb the crystals. Then, heat the water over a small flame. The crystals slowly dissolve and colour the warm water rising to the surface. You can see the convection currents.

2. Heat the end of a poker until it is red-hot. Then, in a darkened room, use a torch to throw the shadow of the poker on to a sheet of white paper. You will see the shadows of the rising currents of warm air from the poker.

3. Ignite some tissue paper and drop it into a tall jar. The burning paper is extinguished because of lack of air.

Again, drop burning tissue paper into a tall jar but, this time, slide a card down the middle of the jar. The paper burns rapidly because it has a good supply of air. Used air, which is warm, rises on one side of the card and fresh air is drawn down on the other side of the card.

Making a paper kettle

Make a paper kettle in the way shown opposite. Paper with a smooth surface is best for this.

Half fill the kettle with water and heat it over a small flame. The water boils but the paper does not burn. The heat from the flame is carried upwards by convection currents and is used up in boiling the water; the paper does not become hot enough to ignite.

Two convection toys

Cut out a paper snake. Use plasticine to fix a pin to one end of a stiff wire. Push the pin through the head of the snake so that it is free to turn. Hold the snake over a lighted candle. The snake turns and twists. Why?

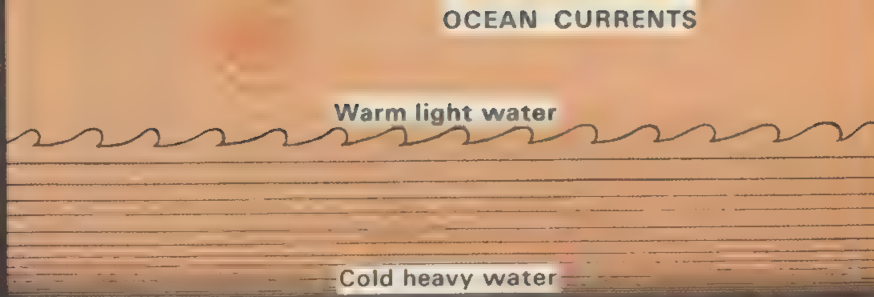
Cut out a paper fan, about 5 centimetres across, with 8 blades. Support it on a pin and wire as you did with the snake. Hold the fan over a candle. The fan revolves. Why?

MORE THINGS TO DO

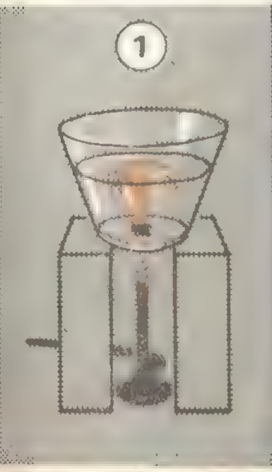
1. Copy the drawings shown in the black frames opposite.

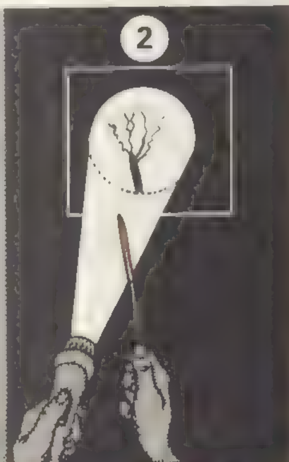
2. Write a few sentences about convection currents.

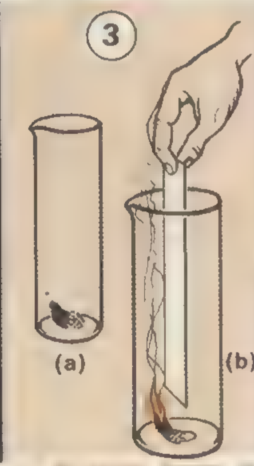
Convection currents

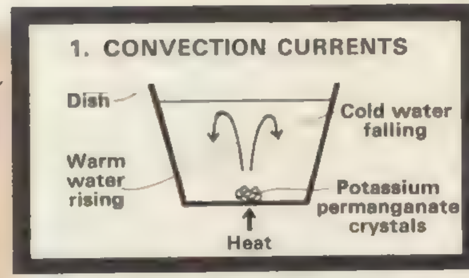


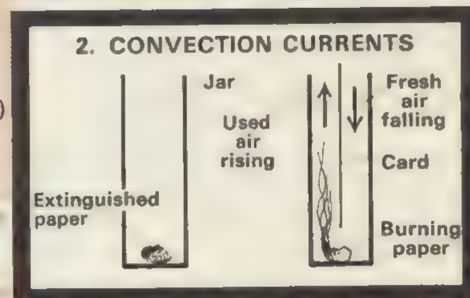
SOME CONVECTION EXPERIMENTS











Simple drawings for your notebook

MAKING a PAPER KETTLE

1. Smooth paper, 6 inches square
2. Fold to make a triangle
3. Fold as shown
4. Fold again as shown
5. Pull down the top flaps
6. Fit a wire handle
7. Fill the kettle with water and boil it

TWO CONVECTION TOYS

19 Moving air

Convection currents in air

Perhaps you have seen tiny specks of dust rising in a shaft of sunlight. They are carried upwards by convection currents of warm air.

On a calm day, the smoke from a chimney rises. The smoke is carried upwards by a current of hot air from the fire.

Winds and breezes

Winds are moving air. They are caused by convection currents. Air, warmed by the sun, rises and cold air rushes in to take its place.

Land and sea breezes are also caused by convection currents. Some of the pictures opposite show how breezes tend to blow from the sea during the day and from the land during the night.

Using convection currents

Gliders are kept aloft by rising currents of warm air.

An airing cupboard usually contains a hot water tank. Blankets, sheets, etc. stored in the cupboard are kept free from damp by the convection currents of warm air rising from the tank.

Rooms are heated by currents of warm air from fires and radiators.

A chimney helps a fire to burn well. Hot air rises up the chimney and air is drawn into the fire.

Convection currents help with the ventilation of rooms. Warm air rises up the chimneys and fresh air is drawn in at the windows and doorways.

At one time, coal-mines were ventilated in a dangerous way which often caused explosive gases to be ignited. A fire was lit at the bottom of one shaft which behaved as a chimney. Warm air rose up this shaft. Fresh air was drawn down another shaft.

When a match is struck, its head is held downwards and not upwards. This is done so that the hot air from the flame, which rises upwards, helps the match-stick to burn.

Roman central heating

The Ancient Romans had a kind of central heating. Hot air from *charcoal* fires was drawn by convection currents through spaces below the tiled floors of their buildings. Charcoal is a smokeless fuel.

Showing convection currents in air

1. Make a long tube by glueing together, end to end, three cardboard tubes from toilet rolls. Hold the tube at an angle with its lower end near a piece of smouldering paper. Hold a lighted candle near to the upper end of the tube. The smoke from the paper rises up the tube. What is happening?

2. Hold a piece of smouldering paper near the bottom of a door which is just open and leads into a warm room. What happens to the smoke from the paper? Can you explain this?

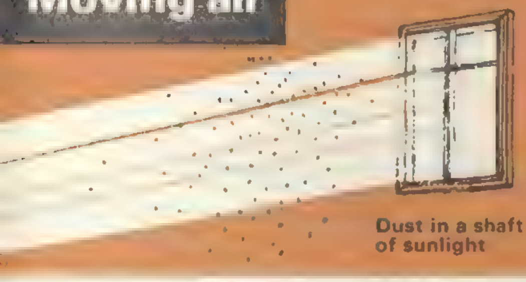
3. Place a lighted candle on the hearth of a fireplace which contains a fire. How does the candle flame burn? What happens to the smoke from the candle?

MORE THINGS TO DO

1. Make drawings to show how winds and land and sea breezes are caused.

2. Make a *mobile* in the way shown opposite.

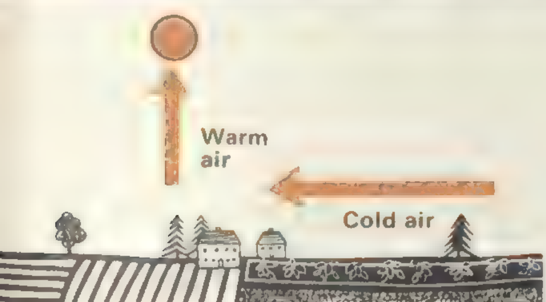
Moving air



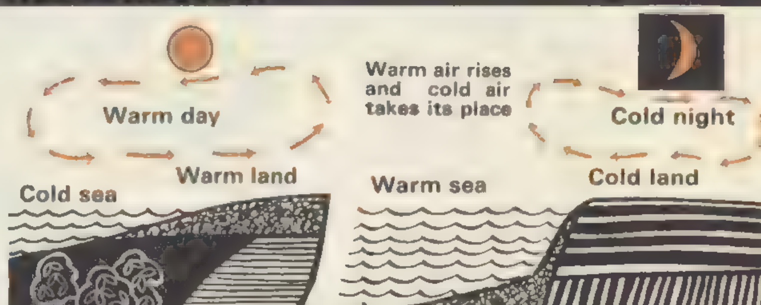
MOBILE

Twist thin wires together to make an odd-shaped mobile. Use thread to fix postcards, magazine pictures, etc. to make a display of sea-side scenes, wild flowers, animals, etc. Tie a thin string to the top of the mobile and hang it above a radiator. Currents of warm air from the radiator will keep the mobile moving.

WINDS AND BREEZES



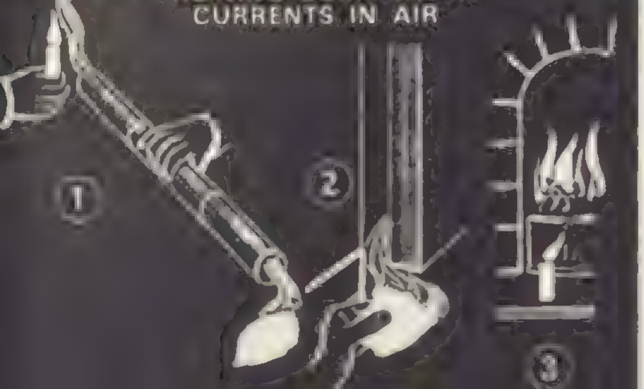
Winds



Land and sea breezes

ROMAN CENTRAL HEATING

SHOWING CONVECTION CURRENTS IN AIR

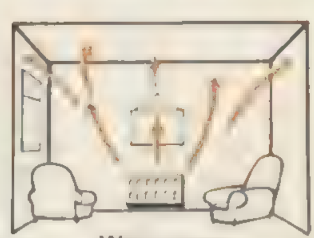


USING CONVECTION CURRENTS

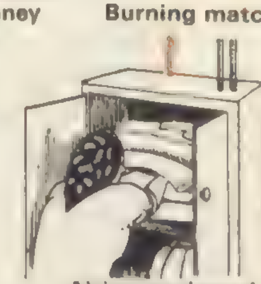
Glider

Chimney

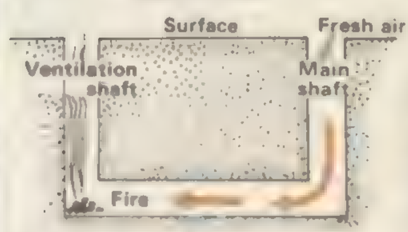
Burning match



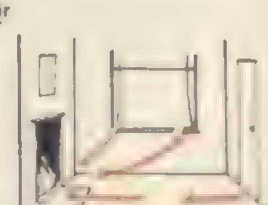
Warm room



Airing cupboard



Coal-mine ventilation



Ventilation

20 Hot water

Hot water in the home

Hot water can be obtained from a kettle, but a modern house usually has a handy supply of hot water at the kitchen sink.

In some houses, the hot water is heated by an *electric immersion heater* which is fitted inside a hot water tank. When the water is hot, the heater switches off automatically; when the water begins to cool, the heater switches on again.

An *instantaneous water heater* provides small amounts of hot water. The water flows through a coiled metal pipe which is heated by a gas or an electric heater. The tap which turns the water on and off also switches the heater on and off.

Many houses have a *hot water system* which supplies hot water to the bath and all the sinks. The water is heated in a boiler at the back of the kitchen grate.

A hot water system

A hot water system is shown on the page opposite.

The water is carried around the system by convection currents; the hot water rises and the cold water falls. The arrows show the direction in which the water flows. The hot water is shaded orange and the cold water is shaded black.

Here are the parts of the hot water system and what they do.

Kitchen grate. Contains the fire that heats the boiler.

Boiler. Fitted in the back of the grate. Contains water which is heated by the fire.

Pipe A. Carries the hot water from the boiler to the hot water tank.

Hot water tank. Stores the hot water from the boiler. In this way, a small boiler is able to heat a large quantity of water.

Pipe B. Carries cold water from the bottom of the hot water tank to the boiler where it takes the place of the hot water which is rising up pipe A.

Cold water tank. Stores cold water which replaces that taken from the system by the taps. The cold water tank is in the roof.

Pipe C. Carries cold water from the cold water tank to the bottom of the hot water tank.

Pipe D. Carries hot water to the bath and sink taps.

Taps. Make the hot water available. When one or more taps are turned on, the head of pressure of the water in the cold water tank forces hot water along pipe D to the taps.

Air escape pipe. Allows any air in the system to escape.

Supply pipe. Carries water from the main pipe into the cold water tank.

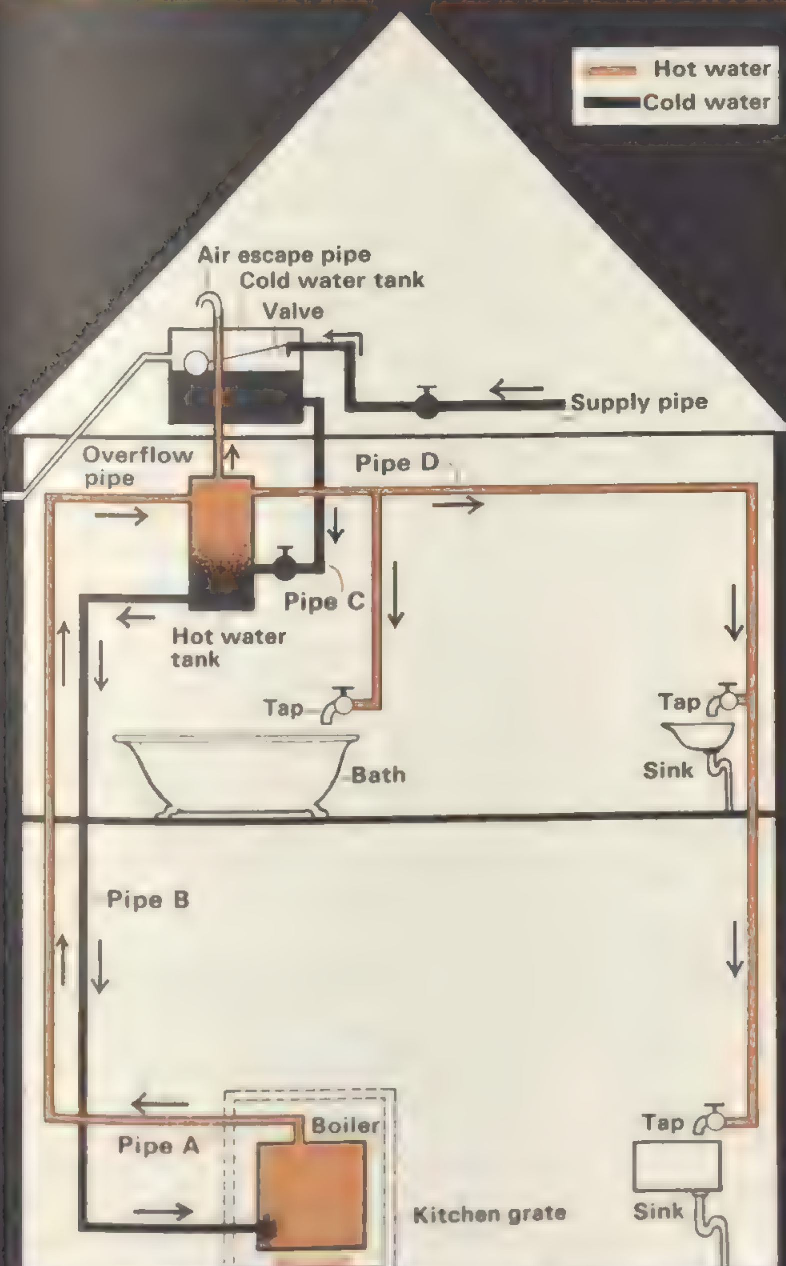
Valve. Controls the flow of water from the supply pipe so that the tank does not overflow.

Overflow pipe. Allows the water to escape if the valve fails to work.

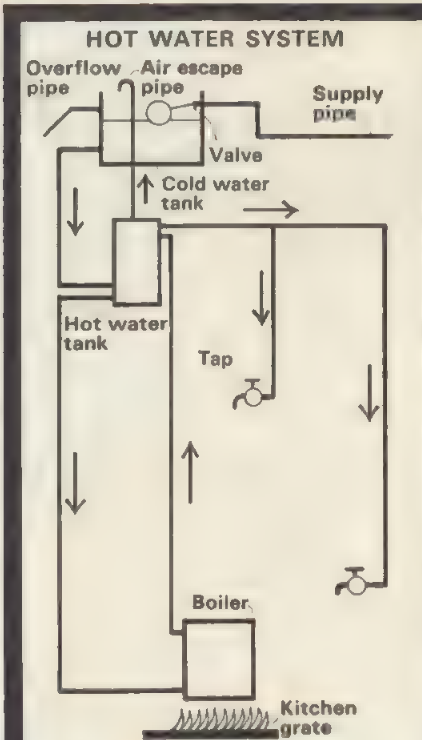
MORE THINGS TO DO

1. Copy the simple drawing of a hot water system shown opposite.
2. If there is a hot water system in your own house, look for the boiler and the hot water tank.

Hot water



HOT WATER SYSTEM



21 Heat radiation

Radiation

When a pebble is dropped into a pond, ripples travel across the surface of the water. In the same kind of way, heat and light are radiated through space in *waves*. A fire radiates heat and light waves. A lamp radiates light waves. A wireless station radiates wireless waves.

Heat from the sun

The heat radiated by the sun warms the earth's surface. The sun's heat *rays* are cold. It is the surfaces on which they fall that become warm.

The sun's rays cannot reach a person who is under a sunshade. The sunshade becomes hot; the person remains cool.

Why do we have dull days? The sun is always shining but, sometimes, it is cloudy; all the sun's rays cannot pass through the clouds.

It is easy to get sunburnt on the top of a mountain because, there, the atmosphere is very thin and cannot act as a shield against the fierce rays of the sun.

Good and bad heat reflectors

Bright, polished surfaces are good heat *reflectors*. Also, they reflect heat in the same way that a mirror reflects light. That is why electric fires have polished reflectors and radiators sometimes have "silvered" surfaces. The air around radiators is warmed by convection currents. *Radiators* are really *convectors*.

The fender around a fireplace is brightly polished. It radiates and reflects heat into the room.

In hot countries, people wear white clothing and whitewash the outsides of their houses. Why do they do this?

Dark, unpolished surfaces are bad heat reflectors. In fact, they absorb heat. Gardeners mix soot, which is black, with soil so that the soil will absorb heat. Plants grow better in warm soil than in cold soil.

Some heat radiation experiments

1. Hold your hand beneath an electric lamp which is on. Your hand feels warm. Air is a poor conductor and convection currents of warm air rise upwards. Heat must reach your hand by radiation.

2. Hold a book between your hand and the lamp. Your hand feels cool. Why?

3. Hold a sheet of glass between your hand and the lamp. Your hand feels warm because heat rays, can pass easily through glass.

4. Move your hand away from the lamp. It feels cool. The air absorbs most of the heat radiated by the lamp.

5. Cover a thermometer bulb with black cloth. Cover another thermometer bulb with white cloth. Place the thermometers side by side beneath the lamp. Which thermometer shows the greater rise in temperature? Why is this?

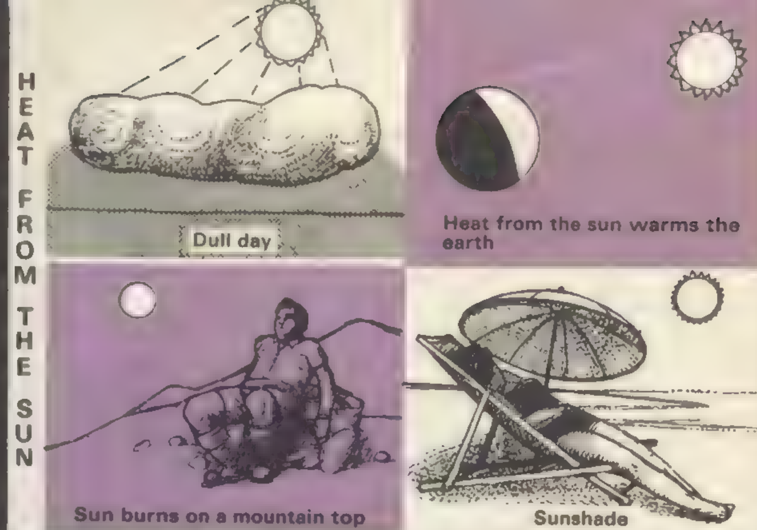
6. Paint one half of the inside of a can black. Use wax to attach two pennies to the opposite sides of the can. Lower the white-hot tip of a poker into the middle of the can. Which coin drops first? Why?

MORE THINGS TO DO

1. Make simple freehand drawings of *three* of the heat radiation experiments.

2. Write a few sentences about good and bad heat reflectors.

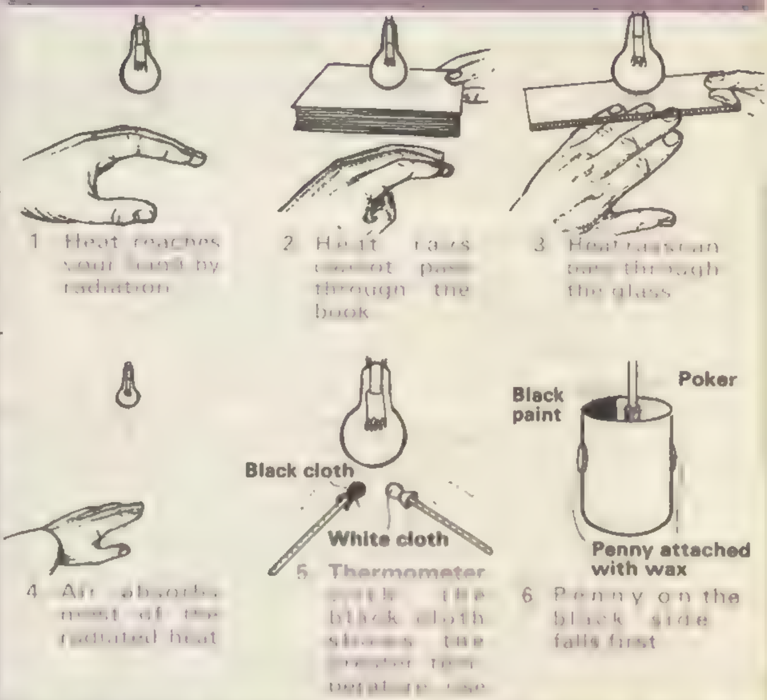
3. Make a *Dutch oven* in the way shown opposite. You can do this at home. Perhaps your mother will use the oven.



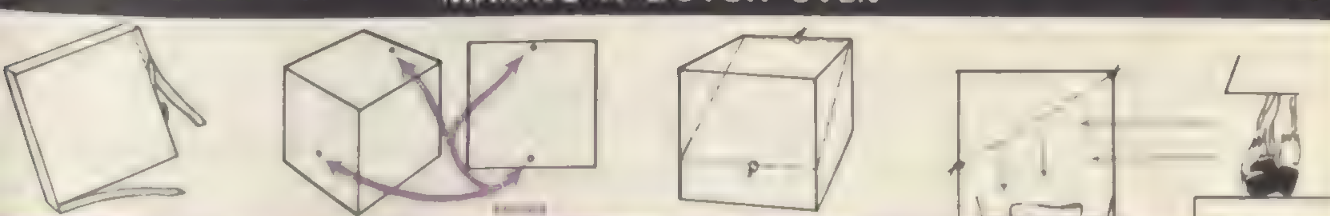
Heat radiation

GOOD AND BAD HEAT REFLECTORS

SOME HEAT RADIATION EXPERIMENTS



MAKING A DUTCH-OVEN



1. Use an old pair of scissors to cut away the rim of a biscuit tin lid

2 Use a hammer and a nail to punch holes in the lid and the tin where shown

3. Use wire to fix the lid inside the biscuit tin

4. Put a dish of meat in the oven. Place the oven in front of a fire. The heat radiated by the fire and reflected by the lid cooks the meat

22 Frames and flasks

Garden frames

Seeds will not begin to grow if they are cold. Young plants are killed by frosts. That is why, in early spring, when the weather is cold and there are frosts at night, gardeners grow seeds and young plants inside *garden frames*. The frames give the seeds and young plants the warmth they need.

Why is it warm inside a garden frame? A garden frame has a glass lid. Heat from the sun passes through the glass by radiation and warms the air inside the frame. This heated air cannot escape and so it becomes much warmer than the air outside the frame.

Greenhouses

Greenhouses are heated by coal, oil or electricity, but, as well, they are heated by the sun's radiation in the same way that garden frames are heated.

How a garden frame works

Push two laboratory thermometers, with their bulbs pointing upwards, into soil in large plant pots. Cover one of the thermometers with a jar. Stand the pots in the sunshine.

After a few hours, look at the thermometers. The thermometer inside the jar shows the higher temperature. Why?

Thermos flasks

Thermos flasks, filled with hot coffee, hot tea, ice-cold milk or ice-cold lemonade, are taken on picnics and long journeys. The hot drinks remain hot and the cold drinks remain cold for several hours. There is little rise or fall in the temperature of the liquids.

The inside of a thermos flask is shown opposite.

The glass bottle inside the metal or plastic container has a double wall. Air has been removed from the space between the walls of the bottle. This means that heat cannot enter or leave the bottle by conduction and convection.

The bottle is "silvered" on the inside. This "silvering" prevents heat from entering or leaving the bottle by radiation. The "silvering" reflects any heat rays.

The bottle is supported on pads of felt or cork. Felt and cork are good heat insulators.

The cork stopper is a good heat insulator.

The cap of the flask is used as a cup.

Inside a thermos flask

Perhaps your teacher has an old thermos flask that he will allow you to examine. Unscrew the bottle and remove it from its container. Look at the "silvering". Is the bottle light or heavy in weight?

Using thermos flasks

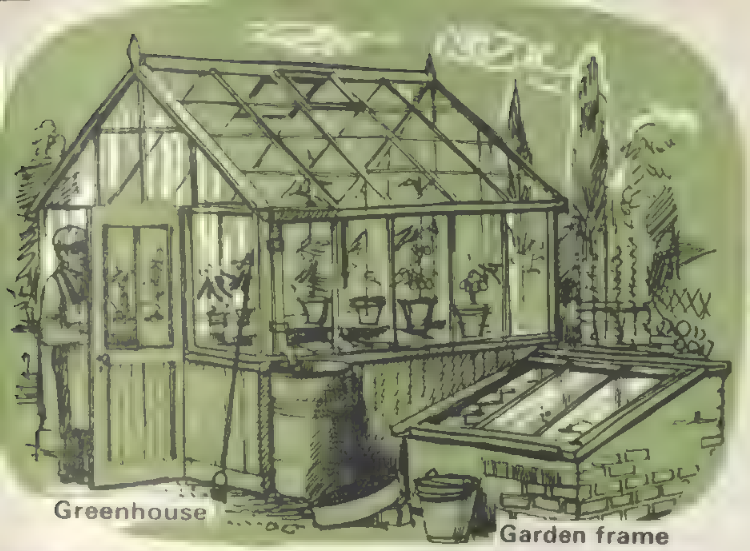
Fill three thermos flasks with hot water. Place the stopper in one of the flasks and screw on the cap. Leave the stopper out of the second flask and screw on the cap. Let the third flask remain open.

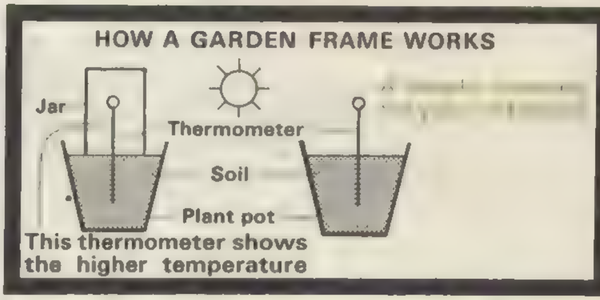
After about ten hours, lower a thermometer into each of the flasks in turn. Which flask contains the hottest water? Which contains the coldest? What has happened?

MORE THINGS TO DO

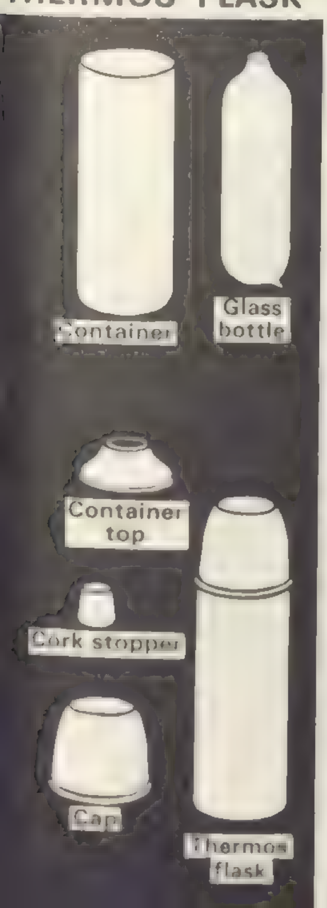
1. Copy the drawings shown in the black frames opposite.
2. Draw a garden frame.

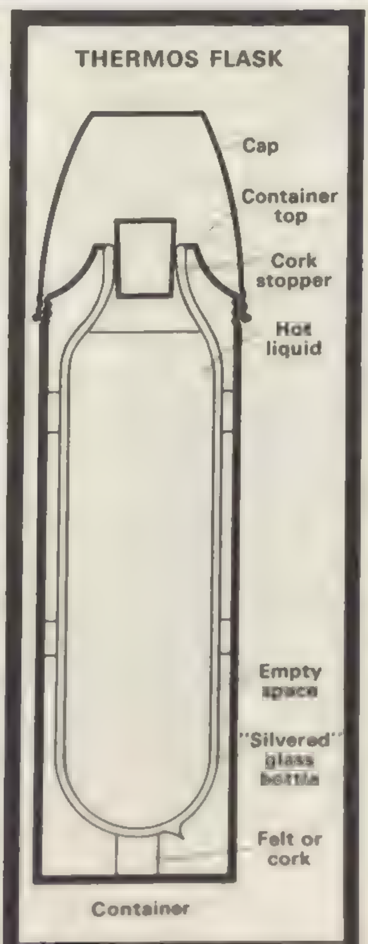
Frames and flasks

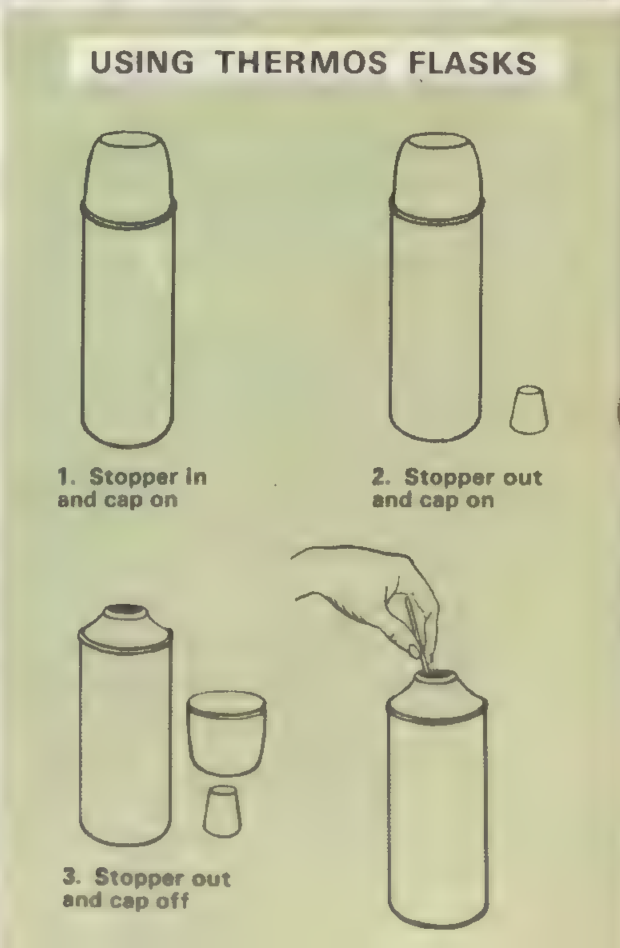




THERMOS FLASK







23 Shake the bottle

A bottle of medicine

Perhaps you have looked at the label on a bottle of medicine and wondered why it has on it the words "*shake the bottle*".

A bottle of medicine sometimes contains a powder which does not dissolve in water. The powder settles at the bottom of the bottle. If the bottle is shaken just before the medicine is poured out, then the powder floats in the liquid and does not remain behind in the bottle. It is most important that the powder should be taken as well as the liquid.

Suspensions

Some powders do not dissolve in water, but, if they are shaken up in water, the very tiny particles of powder float about inside the water. Powders floating about in water are called *suspensions*.

Making a suspension

Half fill a bottle with water and put into it a teaspoonful of chalk powder. Cork up the bottle and then shake it well. The water now looks like milk. Can you see the tiny particles of chalk?

After ten minutes, look at the bottle. Has the chalk powder settled at the bottom of the bottle?

Solutions

When sugar is put into a cup of tea and the tea is stirred, the sugar disappears. It becomes a part of the water and is no longer solid. But, the sugar is still there even though it cannot be seen. It can be tasted. We say that sugar *dissolves* in water.

Water with something dissolved in it is called a *solution*.

The liquid part of a solution is called the *solvent* and the thing dissolved in it is called the *solute*. When salt is dissolved in water, a *salt solution* is made. The water is the solvent; the salt is the solute.

All things do not dissolve in water. For example, sand and wood do not dissolve in water.

Making a salt solution

Put about a quarter of a litre of water into a saucepan. Stir a tablespoonful of salt in the water until all of it has dissolved. Dip one of your fingers into the salt solution and then lick the finger. What do you taste?

Boil the water in a saucepan. As soon as all the water has boiled away, turn off the heat. Allow the saucepan to cool and then taste the white substance on the bottom of the saucepan. Is it salt?

Dissolving things

Shake a little of each of these things, in turn, in water in a jar. Notice which things dissolve and which do not.

Sugar; *Epsom salt*; sand; iron filings; baking soda; sawdust; small pieces of paper; *borax*; washing soda; shavings of candle wax.

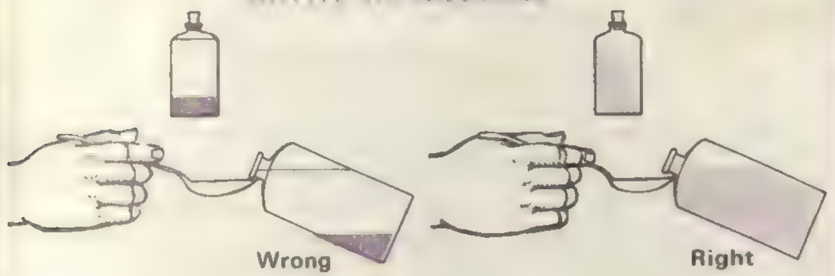
MORE THINGS TO DO

1. Make two lists, in the way shown opposite, of things that dissolve in water and things that do not dissolve in water.

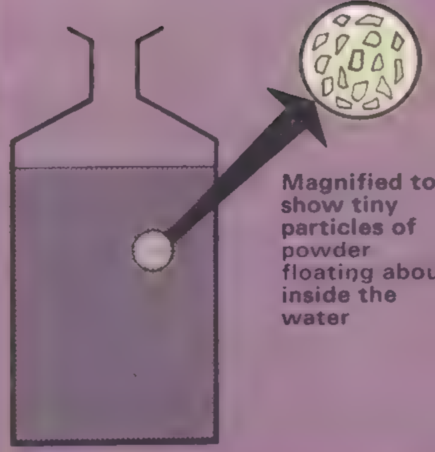
2. Write one sentence about each of these words in a way which shows that you know what the word means.

Suspension; dissolves; solution; solvent; solute.

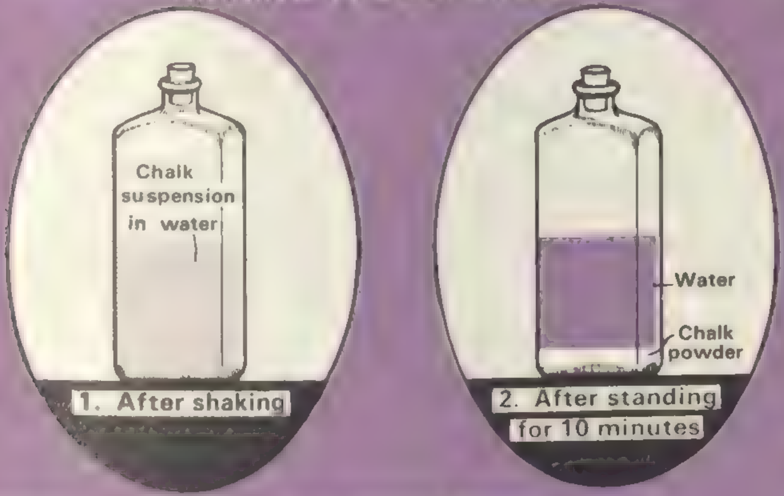
Shake the bottle



Pouring out medicine



MAKING A SUSPENSION



SOLUTIONS

Solvent + solute = solution

Water + sugar = sugar solution
Water + salt = salt solution

Dissolve in water	Do not dissolve in water
Sugar	Sand

24 Acids and alkalis

Acids

Vinegar, lemon juice and the juices of unripe fruits taste sour because they contain *acids*. Acids taste sour.

You must take care with acids. Vinegar and lemon juice are harmless, but some acids, like the acid in a *car battery*, are poisonous and may burn your skin and clothing. *These acids should be neither touched nor tasted.*

Some dyes change colour when they are brought into contact with acids. One of these dyes is *litmus*. Litmus is blue. An acid will cause its colour to change from *blue* to *red*.

Many metals will dissolve in acids. If a piece of *zinc* or *magnesium* is put into battery acid, it slowly dissolves and bubbles of *hydrogen gas* are given off.

Have you seen the *verdigris* on a brass spoon which has been standing in vinegar? The vinegar has dissolved the surface of the spoon to make a substance that is green.

Hydrogen

Hydrogen gas is colourless and has no smell. It will burn very quickly in air. It is the lightest gas known. It is used for filling balloons.

Alkalis

Caustic soda and *ammonia* are called *alkalis*. Caustic soda is used to remove grease. *Smelling salts* contain ammonia.

Alkalis will cause litmus to change its colour from *red to blue*. Alkalis feel soapy. But, *you must neither touch nor taste alkalis*. Caustic soda dissolves plant and animal materials. You can imagine what caustic soda would do to your skin. Alkalis dissolve grease.

Testing for acids and alkalis

Test some of the following things with *litmus paper* and find out which contain acids and which contain alkalis. Most of these things can be found in the kitchen at home. For each test, use two litmus papers, one blue and one red. Notice which paper changes colour. Place the litmus papers on cut surfaces of the onion and the fruits.

Make two lists – things that contain acids and things that contain alkalis.

Vinegar; onion; battery acid; washing soda solution; baking soda solution; gooseberry; sour milk; orange; lemon; sour beer; sour wine; cider; ammonia; apple; blackcurrant juice; rhubarb; soap solution; washing powder solution; tomato; grapefruit; solution of bath salts.

Acids dissolve metals

Pour a little battery acid into a test-tube. Drop a short piece of *magnesium ribbon* into the acid. What happens to the magnesium?

Ignite a piece of paper and hold it in the mouth of the test-tube. There is a "pop". What gas is given off by the acid?

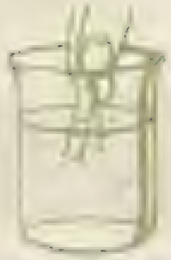
Put copper wire in a jar of fruit juice or vinegar. After a few hours, look at the copper wire. What has happened?

MORE THINGS TO DO

1. Write one sentence about each of these words in a way which shows that you know what the word means.
Acid; litmus; verdigris; alkali; ammonia.
2. Write a few sentences about hydrogen.

Litmus papers

Testing fruits

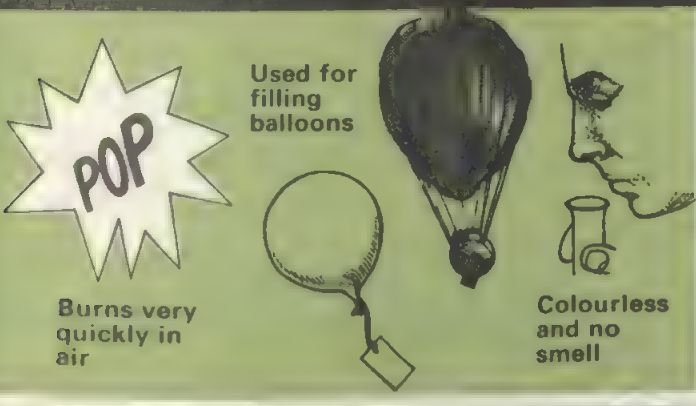


Testing liquids

Acids and alkalis

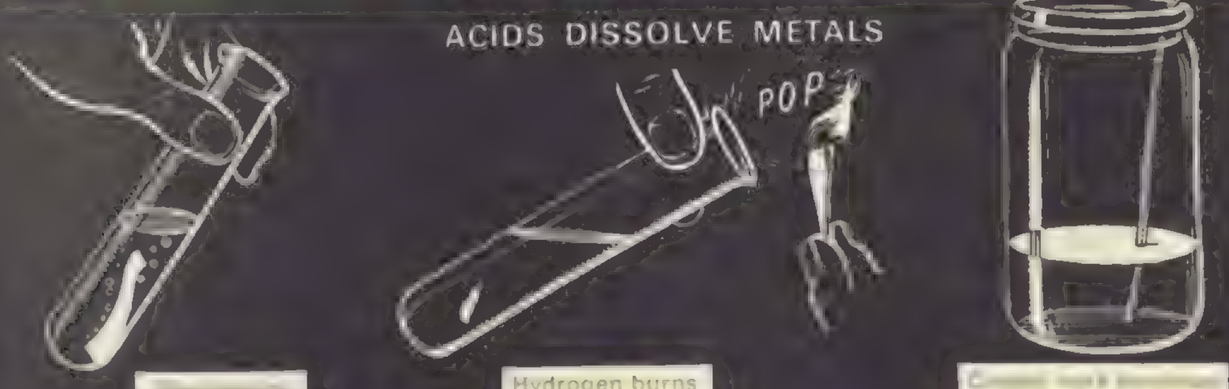
TESTING FOR ACIDS AND ALKALIS

HYDROGEN



THINGS THAT CONTAIN ACIDS	THINGS THAT CONTAIN ALKALIS
Vinegar	Washing Soda
Battery Acid	Ammonia

ACIDS DISSOLVE METALS



dissolves in battery acid

Hydrogen burns with a "pop"

25 A visit to the zoo

Zoo animals

Suppose that you are on a visit to the zoo. Some of the animals that you would expect to see are shown opposite. They are very different in their colours, shapes and sizes. Which is the largest of the animals shown? Which is the tallest? Which is the smallest?

What is an animal?

All living things are either *plants* or *animals*, and, therefore, any living thing that is not a plant must be an animal. Some people speak of "fishes, birds and animals" as if fishes and birds were not animals, but, of course, fishes and birds are animals. Insects, spiders and snails are animals too.

The animal kingdom

The animal kingdom can be divided into two main groups of animals – those *with backbones* and those *without backbones*.

Some animals with backbones are: rabbit, sparrow, toad and goldfish.

The skeleton of a rabbit is shown opposite. Can you see its backbone?

Some animals without backbones are: earthworm, oyster, bee and crab.

The backboned animals

There are five classes of backboned animals – *fishes, amphibians, reptiles, birds* and *mammals*. Here are some important facts about the backboned animals.

Fishes. Cold-blooded. Live in water; cannot live for long out of water. *Fins.* Some have *scales*. Breathe with *gills*. Lay very many eggs, but many are eaten by water animals.

Amphibians. Cold-blooded. Their *tadpoles* live in water; the adults can live on land as well as in the water. Four legs. Tadpoles breathe with gills; adults breathe with lungs. Lay many shell-less eggs. Frogs, newts and toads are amphibians. Toads live on land. Newts live in water.

Reptiles. Cold-blooded. Mainly land animals. Some have four legs; some are without legs. Scales. Breathe with lungs. Lay a few soft-shelled eggs. Snakes, lizards, turtles, tortoises and crocodiles are reptiles.

Birds. Warm-blooded. Wings. Some, like the ostrich and penguin, cannot fly. Feathers. Breathe with lungs. Lay a few hard-shelled eggs. Look after their babies.

Mammals. Warm-blooded. Land animals. Four legs. Hair, fur or wool. Breathe with lungs. Do not lay eggs. Give milk to their babies. Look after their babies.

The amphibians are well named for "amphibian" means something that can manage as well in water as on land. During the Second World War, the British Army used *amphibious trucks* for landing on enemy beaches. These trucks had large air-filled rubber wheels which kept them afloat in the sea.

Seals and whales live in the sea but they are mammals because they are warm-blooded and give milk to their babies.

We are mammals.

Look at the zoo animals opposite and decide the class to which each animal belongs. To which class belongs the lady in the ticket office?

MORE THINGS TO DO

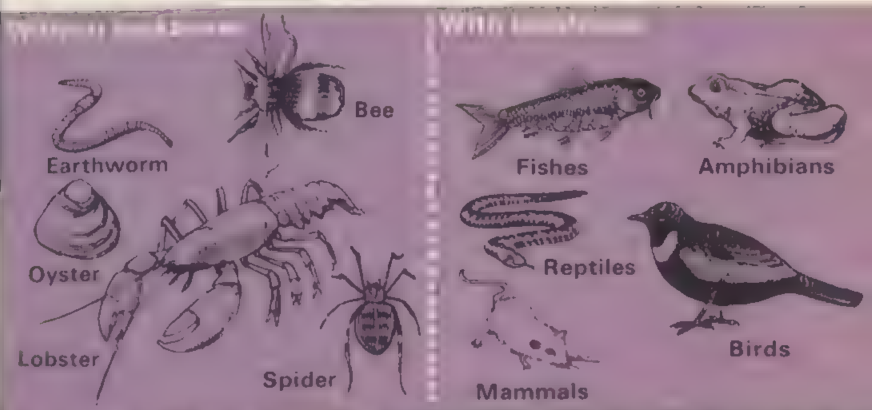
1. Use tracing paper to copy some of the drawings of zoo animals shown opposite. Below each one, print its name and class.
2. Make some animal "cut-outs" in the way shown opposite. You can do this at home.
3. Visit a zoo if you get a chance.

A visit to the zoo

RABBIT'S SKELETON

AMPHIBIOUS TRUCK

THE ANIMAL KINGDOM



ANIMAL "CUT-OUTS"

1. Paste a picture of an animal on thin card

2. Cut round the animal

3. Print the animal's name at the bottom of the "cut-out"

4. Cut a slit in a strip of card to make a support

26 Tame mice

Keeping tame mice

Would you like to keep some mice as pets? You would learn a lot about mammals. Tame mice are no trouble and there is little smell if you clean out their cage fairly often. They soon become very friendly and will do some amusing little tricks for you.

A home for tame mice

The best home for tame mice is a metal cage which is well ventilated. This can be bought at a pet shop. A wooden cage is not suitable because the mice would gnaw holes in the sides of the cage and escape through them.

A cage for two or three mice can be made from a large biscuit tin in the way shown opposite. This is something you could do at home in your spare time.

Cover the floor of the cage with sawdust. This will soak up "toilet" liquids.

Place straw, hay or wood shavings inside the cage. The mice will use this to make a nest in one corner. Also, put a small piece of wood inside the cage. The mice will gnaw this and so keep their teeth sharp and healthy.

Put a small dish of water in the cage because the mice will want to drink.

Stand the cage away from draughts in a warm, shaded place.

Rules for keeping tame mice

1. Feed the mice three times a day.

Morning. A tablespoonful of oats, wheat, barley, oatmeal, maize, porridge oats, canary seed or a mixture of these.

Midday. A little green food – lettuce, watercress, dandelion leaves, chickweed, pea and bean seedlings, groundsel, etc.; a small piece of apple or carrot now and again.

Evening. Bread and milk. Soak brown or wholemeal bread in hot water and then dip it in cold milk. Each mouse needs a quarter of a slice of bread.

2. Remove all uneaten food each day. Sour food is bad for mice.
3. Wash out the food and drinking vessels each day.
4. Change the drinking water each day.
5. Sprinkle sawdust on the floor of the cage each day.
6. Sweep out the cage and put in fresh straw, hay or shavings every week.
7. Wash out the cage with hot water and a little disinfectant every month. The mice can be kept in a shoe box while you are doing this.
8. Handle your mice as often as you can and then they will become tame.
9. Wash your hands after handling mice.

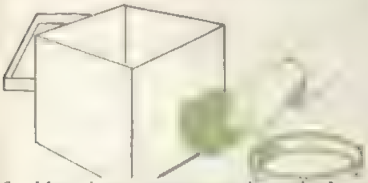
Breeding mice

If a pair of mice are breeding, put a small cardboard box with a small entrance and some cotton wool inside the cage so that the mother mouse will be able to make a nest and have her litter in private. Do not disturb the baby mice, or the mother may kill them.

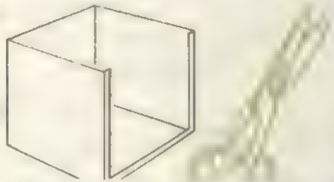
MORE THINGS TO DO

1. Copy the rules for keeping tame mice.
2. Copy "THE TAME MOUSE" table shown opposite.
3. Find out how a mouse uses its whiskers.
4. Find a library book about keeping tame mice. Read it.

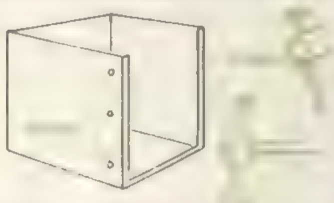
MAKING A MOUSE CAGE



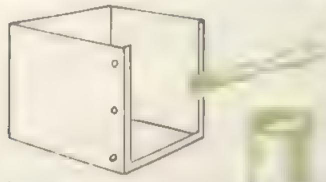
1. Use hot water and a cloth to remove paper on the outside of the tin



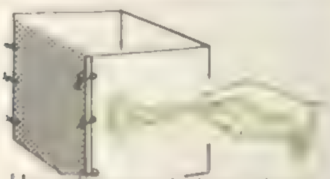
2. Use snips or an old pair of scissors to cut away one side of the tin



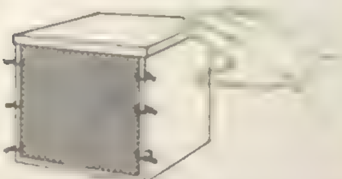
3. Use a hammer and a nail to punch 6 holes where shown.



4. Brush enamel on the cut edges to prevent rusting

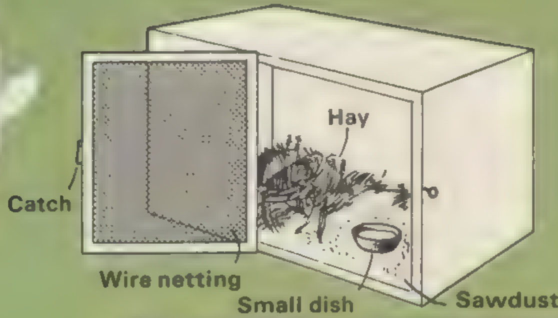


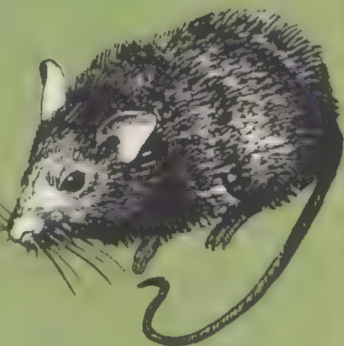
5. Use pliers and short pieces of wire to fasten wire netting on the front of the tin

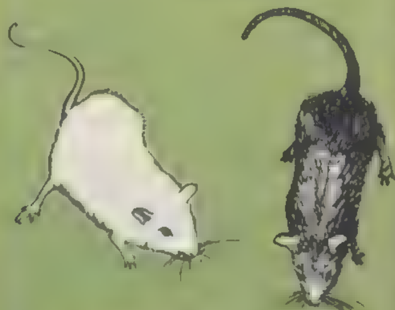


6. Place lid in position and the

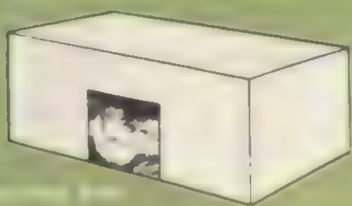
Tame mice







THE TAME MOUSE	
Class	Mammal
Colour	White, grey, black or brown
Female	Called a *doe*
Male	Called a *buck*
Life	About $2\frac{1}{2}$ years
Mating	At any time of the year
Birth of baby mice	3 weeks after mating
Litter	As many as 15 baby mice
Baby mice	Pink. Eyes closed and bodies hairless. Able to look after themselves 3 weeks after birth.
Defence	Sharp teeth and quick movement
Food	Much variety – seeds, bread, fruit, etc.



27 Light and lamps

Fire and light

When men discovered how to make fire, they had fire-light by which they could see at night. Before they discovered how to make fire, they had to depend on sunlight and moonlight, and, as you know, moonlight is very feeble.

What is light?

But, what is light and how does it enable you to see? Light makes things visible. When light rays from a lamp fall on an object, some of the rays are reflected into your eyes and so the object can be seen. There is no light in a completely dark room; nothing can be seen.

Flames, lamps, glow-worms, the sun and the stars make light. We say that they are *luminous*. The moon is not luminous because it does not make light. It is made visible by the sunlight reflected from it.

Lamps

On the page opposite, you can see some of the different kinds of lamps that have been used in past ages.

The people of long ago probably lit their huts and caves with torches which were bundles of dry twigs. They may have dipped the twigs in the fat dripping from roasting meat.

Later on, people found out how to make oil lamps from sea-shells and hollow stones. Today, some Eskimos still use stone and shell lamps. The oil is obtained from seals and other animals. Roman and Greek lamps had channels and spouts to hold the *wicks* in place and to prevent the oil from spilling over.

At one time, the people of the *Shetland Islands* made lamps by pushing wicks through the bodies of very oily birds called *stormy petrels*.

The *beeswax* and *tallow* candles used in the Middle Ages were expensive. Poor people used dried rushes dipped in tallow.

Nowadays, oil lamps are filled with *paraffin*, which is cheap and plentiful.

Most modern lamps are electric lamps, but gas lamps are still in use.

Using a paraffin lamp

Examine a paraffin lamp. What are the purposes of the *screwed cap, glass shade* and *air-hole*? Why is the bottom heavy?

Fill the lamp with paraffin and then light the wick. Alter the size of the flame by turning the screw which lowers and raises the wick. Extinguish the flame by lowering the wick.

Making an oil lamp

Make a simple oil lamp from a glass jar with a metal lid.

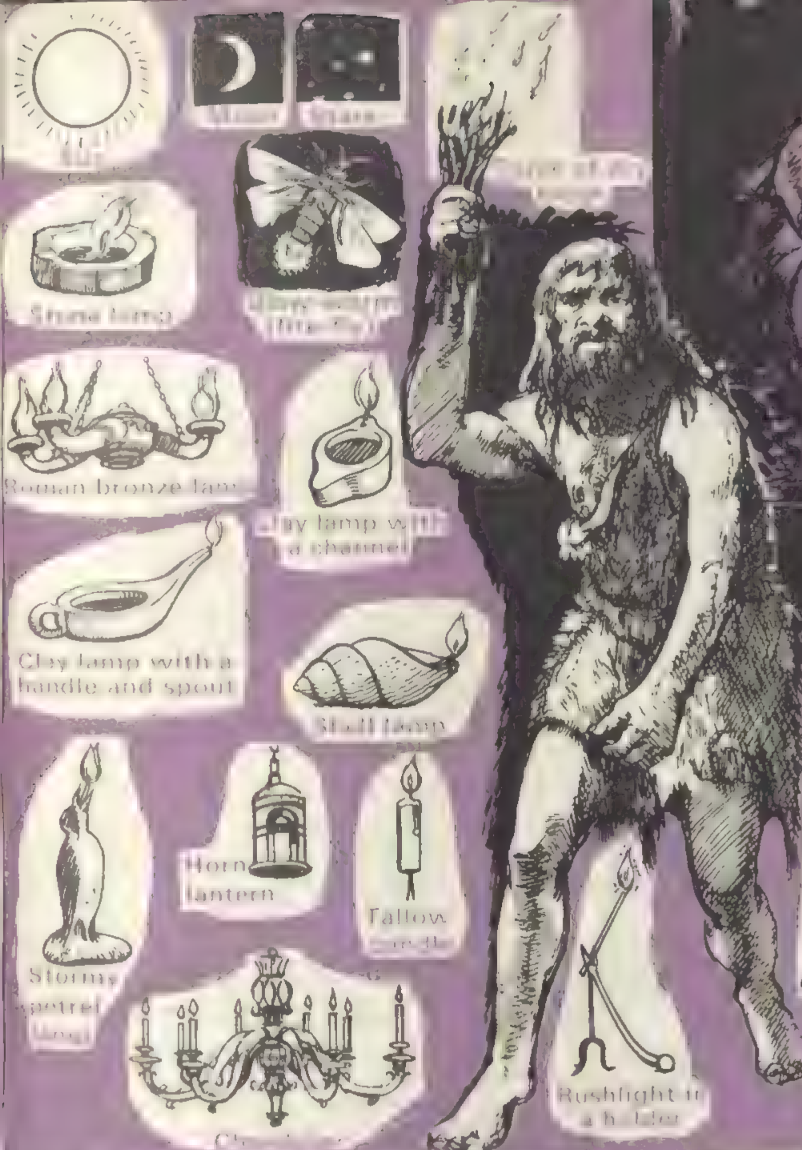
Use a hammer and a nail to punch a small hole and a large hole in the lid. Make a wick of string or cotton wool. Put a little paraffin into the jar and then light the wick. The wick provides a hot surface on which the oil becomes a vapour and mixes with air and so burns easily. What is the purpose of the air-hole? Why is it better to use a glass jar rather than a metal can?

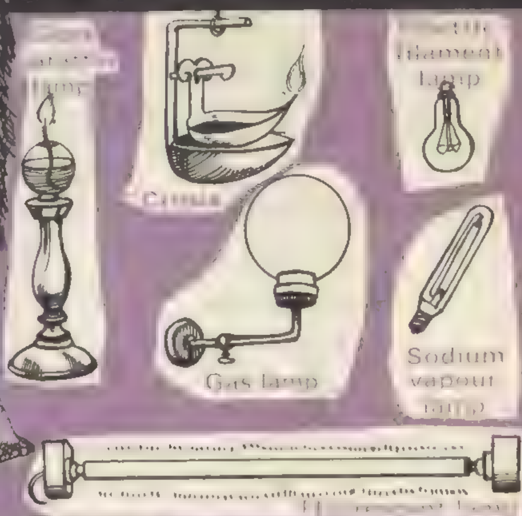
MORE THINGS TO DO

1. Draw some of the lamps shown on the page opposite.
2. Write a short essay with the title *Light and Lamps*.
3. Find the Shetland Islands on a map of the British Isles.


An early man enjoys the warmth and light of his fire

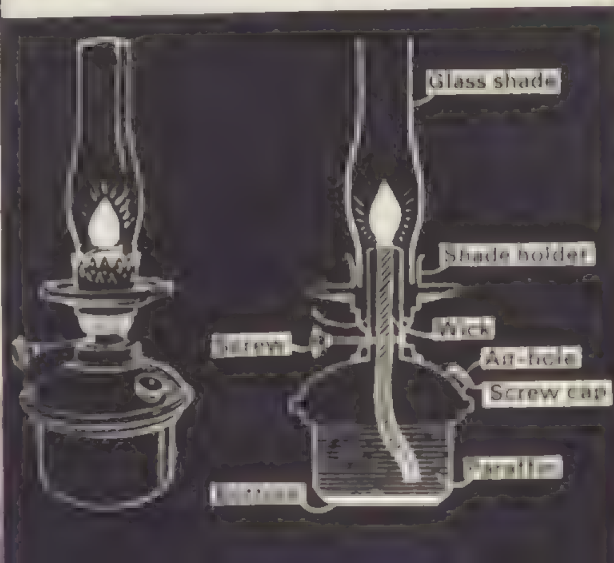
Light and lamps



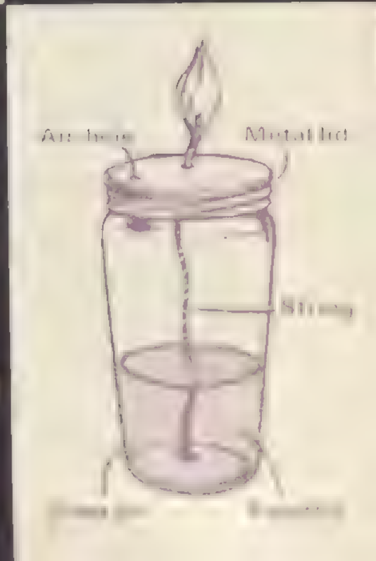


Light makes things visible

PARAFFIN LAMP



SIMPLE OIL LAMP



28 How light travels

The radiation of light

As you know, heat and light travel through space by radiation. Flames, lamps, the sun, the stars and other luminous things radiate light waves.

You can see luminous things because some of their radiated light enters your eyes. You cannot see the stars if you stand with your back towards the sky; no starlight can enter your eyes.

You can see things which are not luminous only when light falls on them; some of the light is reflected into your eyes. You cannot see the sun if you stand with your back towards it, but you can see other things; they are made visible by the sunlight reflected from them into your eyes.

Light waves travel outwards from a luminous thing. They do not change their direction unless they are reflected. That is why we say that "*light travels in straight lines*". No doubt, you have noticed that cinema projectors, torches, motor-car headlamps and lighthouses always give straight beams of light.

Reflected light waves also travel in straight lines. You cannot see around a corner because light reflected from objects around the corner will not turn the corner and then enter your eyes.

Heat rays from the sun

On a sunny day, use a *magnifying glass* to make a bright spot of sunlight on a piece of paper. The paper smoulders after a few seconds. Does sunlight contain heat rays?

Light travels in straight lines

1. Shine a torch in a dark room. Hold a glowing string below the beam. The smoke will make the beam visible. Is the beam straight?

2. Hold a penny between one of your eyes and a candle flame. Bring the penny near to your eye so that you cannot see the flame. Why are you unable to see the flame?

3. Use a pin to make holes in the centres of two postcards. Hold the cards between one of your eyes and a lighted candle. You can only see the light from the flame when your eye, the holes and the flame are in a straight line. Why is this?

4. Make a pin-hole in the centre of a postcard. In a dark room, hold the card between a candle and another postcard. The image of the candle flame is upside down. How does this show that light travels in straight lines?

Darkness and shadow

If something is between an object and light rays, the light rays cannot pass and the object is in darkness. The darkness is called a *shadow*.

Making shadows

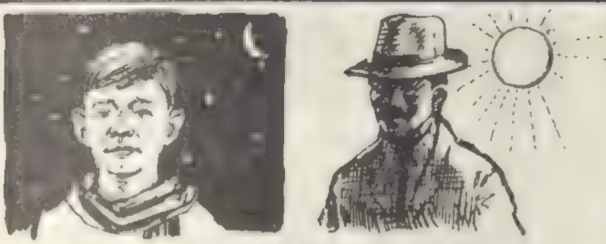
Hold a penny upright between a candle and a postcard. What is the shape of the shadow? The shadow has two parts. The inner part is in complete darkness, but the outer part is not in complete darkness because some light rays fall on it. Turn the penny edgeways. What is the shape of the shadow now?

MORE THINGS TO DO

1. Make freehand drawings of *two* of the "**Light Travels in Straight Lines**" experiments.

2. Write a few sentences about the radiation of light.

How light travels

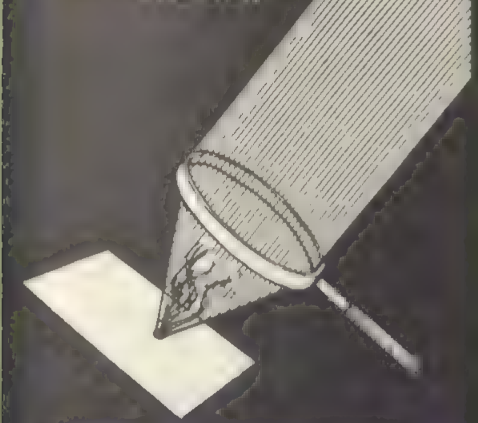


You cannot see the stars and the sun if your back is towards them

Light does not turn around corners

THE RADIATION OF LIGHT

HEAT RAYS FROM THE SUN

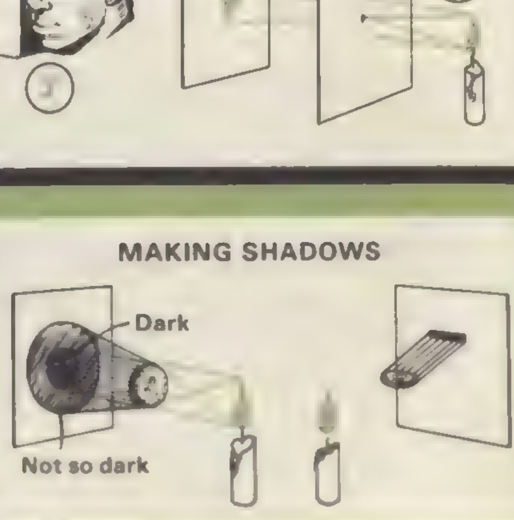


Sunlight contains heat rays

LIGHT TRAVELS IN STRAIGHT LINES

SHADOWS

MAKING SHADOWS



29 Mirrors

Why do mirrors shine?

Mirrors shine because they reflect nearly all the light that falls on them. Sometimes, motorists are dazzled by the sunlight reflected from a wet or smooth road surface. The road surface behaves as a mirror. Moonlight and sunlight are reflected by the surface of the sea. The waves act as moving mirrors and the light is scattered in all directions.

But, all surfaces, even those which are dark and unpolished, reflect some light. Of course, white surfaces reflect more light than do dark surfaces. A room with white walls is brighter than a room with dark walls. A motorist is more likely to be dazzled by glare on a concrete road, which is white, than on a tarred road, which is dark.

Making mirrors

A mirror is usually made by "silvering" one side of a sheet of glass. The "silvering", which is not silver but a mixture of tin and mercury, is held in place with varnish. An unbreakable mirror is a polished sheet of metal.

The *images* seen in water and polished metal ornaments probably gave people the idea of making mirrors. Have you read the Greek story about the youth Narcissus who gazed into a pool of water and fell in love with the image of his own handsome face?

Showing light reflection

1. Shine a torch on a mirror. Hold the torch so that you are dazzled by the light reflected from the mirror.

2. In a dark room, shine a torch on a mirror. Blow smoke from a glowing string on to the reflected beam so that it is seen quite clearly.

3. Hold a mirror so that it reflects sunlight from a window to make a spot of light in a dark part of the room.

4. Polish the outside of a metal spoon and hold it in front of your eyes. What do you see?

Left or right?

Look at yourself in a mirror. Touch your nose with your right hand. Your right hand seems to be your left hand. Your image shows you the wrong way round.

Hold a page of this book in front of a mirror. What do you notice?

Some words printed backwards are shown on the opposite page. Hold the words in front of a mirror. Can you read the words?

Using mirrors

Mirrors have many everyday uses. Shaving would be a difficult business for father if he were not able to see his face in a mirror. A dentist uses a small mirror for viewing the backs of teeth. A car mirror enables a motorist to see the traffic behind him. The "cats' eyes" on a road are glass studs which reflect light from motor-car headlamps so that the sides and the middle of the road can be seen at night. The windows of private offices are often made of frosted glass. It is not possible to see through frosted glass because it has a rough surface which behaves as many mirrors and reflects light in all directions.

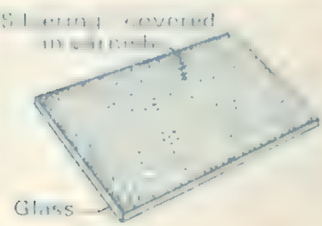
MORE THINGS TO DO

1. Write a few sentences about mirrors.
2. Find out why (*a*) a blind man's stick is painted white and (*b*) a traffic policeman wears white gauntlets.

Dazzle on a road

Mirrors

Moonlight on the sea



Glass mirror

LEFT OR RIGHT?

Your right hand seems to be your left hand

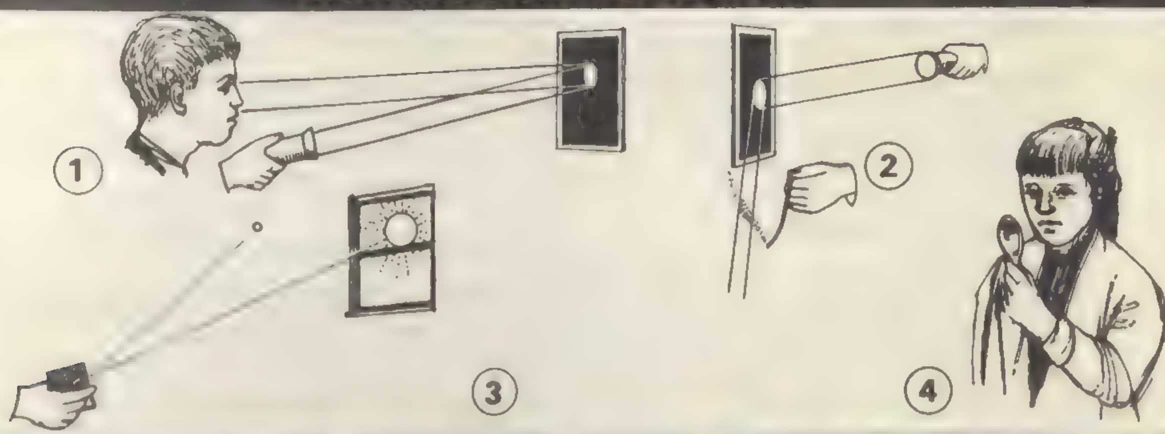
Can you read this?

Metal unbreakable mirror

Polished metal ornament

Narcissus

SHOWING LIGHT REFLECTION



USING MIRRORS

30 Looking around corners

Periscopes

At a football match, you may see a few of the spectators peeping into long boxes. These boxes are *periscopes*. They enable the spectators to look over the crowds.

Periscopes are used for "looking around corners". The simplest kind of periscope is two mirrors arranged so that light rays are reflected from one to the other.

A submarine is fitted with a periscope. The sailors in the submarine can see above the surface of the sea even though the submarine is below the surface.

Using a periscope

Perhaps your teacher has a periscope that he will allow you to use. Use it for looking over a fence, around a corner, etc.

How light is reflected

A ball bounces off a wall at the same angle as it strikes the wall. In the same kind of way, light rays "bounce off" a surface. One of the pictures opposite shows a beam of light striking a mirror. *Angle A* is the same as *angle B*. Scientists call this the *law of reflection*.

The law of reflection is used in the making of periscopes. If the mirrors are set at the correct angles, light rays are reflected along a certain path.

The law of reflection

Throw a tennis ball at a wall several times. What do you notice about the angles at which the ball strikes and bounces off the wall?

Draw a line on a sheet of paper. Stand a square mirror on the line. Support the mirror with a lump of plasticine. Stick two pins, which we will call A and B, into the paper on the left of the mirror. Now, stick two pins, which we will call C and D, into the paper on the right of the mirror. Look along C and D and arrange their positions so that they are in line with the images of A and B. Remove the mirror. Join the pins with pencil lines and then remove the pins. Is the angle between the mirror and A and B the same as the angle between the mirror and C and D?

Seeing through a book

Place a large book on a table. Arrange four mirrors around the book in the way shown opposite. Support the mirrors with plasticine or corks. Shine a torch on the mirror at the left. Look at the mirror at the right. You are dazzled by the beam of light from the torch. Do you really see through the book? What is done by the mirrors?

Images of images

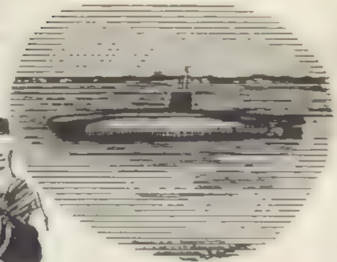
Stand two mirrors so that they are at an angle of 60°. An angle of 60° is shown opposite. Support the mirrors with plasticine. Place a cork or some other small object between the mirrors. You will see not only two images, but images of the images.

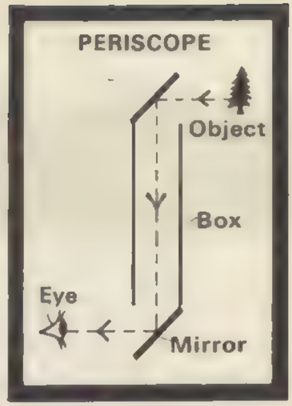
MORE THINGS TO DO

1. Copy the drawings shown in the black frames opposite.
2. Make a periscope in the way shown opposite. You can do this at home.

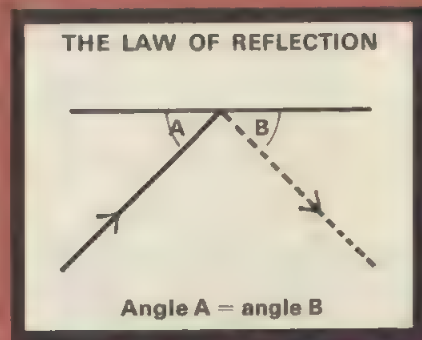
Looking around corners

PERISCOPES

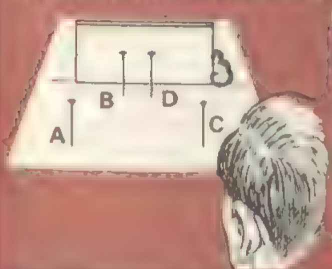


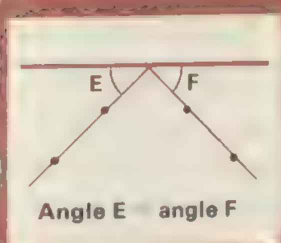


HOW LIGHT IS REFLECTED



THE LAW OF REFLECTION

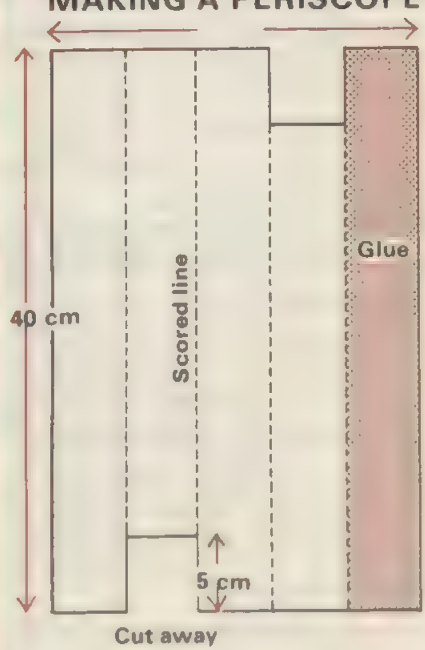




SEEING THROUGH A BOOK

IMAGES OF IMAGES

MAKING A PERISCOPE



Finished periscope

Use a knife to score lines, 5 cm apart, on a piece of card, 40 cm long and 25 cm wide. Cut away 5 cm of card from each end. Glue and fold the card to make a square tube. Glue two 5 cm square mirrors in the top and bottom of the tube

31 Bending light rays

"Bending" a pencil

Pour water into a glass jar until it is about three-quarters full. Lean a pencil against the inside wall of the jar. Look at the side of the jar. The pencil seems to bend at the surface of the water.

The refraction of light

Light rays bend as they pass from one *transparent* material to another. A transparent material is one through which you can see. Glass, water and air are transparent. Wood, iron and lead are not transparent.

The bending of light rays is called *refraction*. The drawing in the blue frame opposite shows how refraction makes a pencil in water appear to be bent. The light rays from the bottom part of the pencil bend as they pass out of the water into the air. The rays seem to come from A and not B.

Refraction causes a clear stream or pool to seem not so deep as it really is. Refraction causes things seen through a window to appear to be distorted. The surface of a pavement seems to shimmer on a hot, sunny day because the hot air above the pavement rises upwards and the rays of sunlight reflected by the pavement pass through the moving air and are refracted in all directions.

The depth of water

Place a penny on the bottom of a dish of water. The water seems shallower than it really is. Why is this?

Making a penny appear

Place a penny on the bottom of an empty cup. Look down into the cup so that you are just not able to see the penny. Fill the cup with water and the penny comes into view. Why can you see the penny now?

Shimmering air

Support a tile on two building bricks. Place a lighted bunsen burner under the tile. After a few minutes, look at the air above the tile. What do you see?

Spearing fish

In some parts of the world, people catch fish by spearing them. This needs much skill for the fish swim quickly and are deeper than they seem to be.

Mirages

Desert travellers often see water in the desert, but they are mistaken. The water is not real. It is a *mirage*. A mirage is caused by the reflection and refraction of light in the hot air above the sand. The reflection of the blue sky by the sand looks like water.

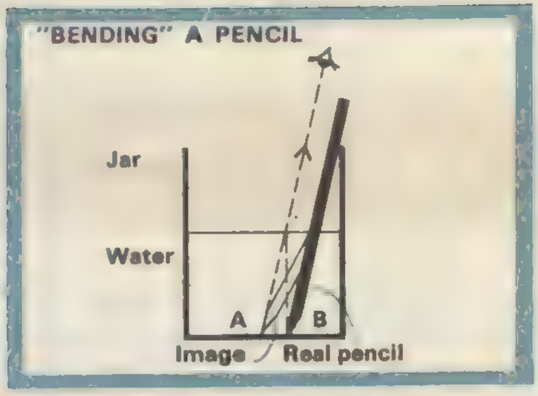
On a hot day, you sometimes see what appear to be pools of water on the smooth surface of a tarred road. These pools of water are mirages.

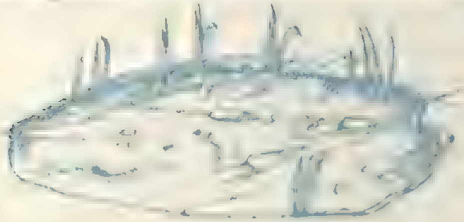
Have you heard of the *Flying Dutchman*? Legends tell us that this ship sails the ocean without a crew. Some sailors claim to have seen this ship, but, without a doubt, it is a mirage.

MORE THINGS TO DO

1. Copy the drawings shown in the black frames opposite.
2. Copy the drawing shown in the blue frame opposite.
3. Write one sentence about each of these words in a way which shows that you know what the word means.
   Refraction; transparent; mirage.
4. Use an encyclopedia to find out what you can about the *Flying Dutchman*.

Bending light rays

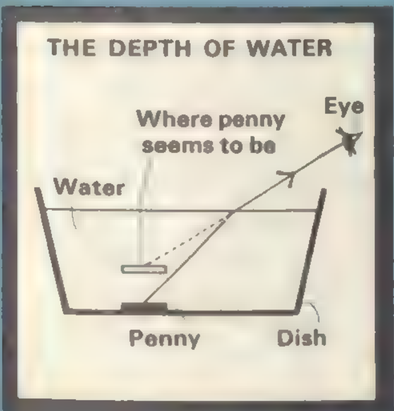


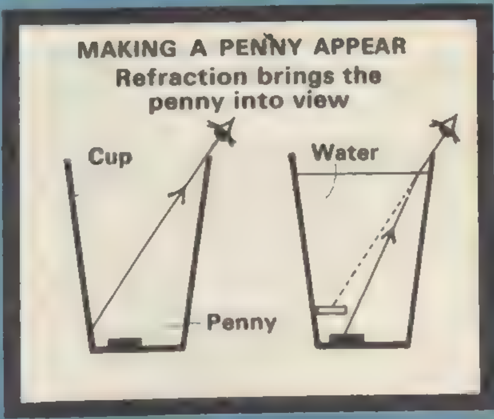


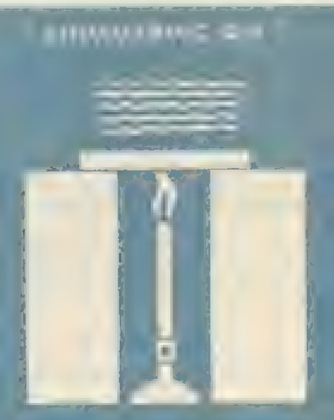
A clear pool seems shallow

A window distorts things

A shimmering pavement



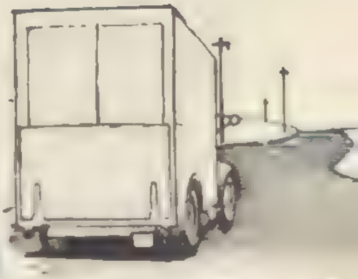




MIRAGES

Pools of water in the desert

The Flying Dutchman?



Pools of water on a hot road

32 Bigger and nearer

Using a magnifying glass

Look at hairs, petals, woollen and cotton threads, insects and other small things through a *magnifying glass*. These things are magnified; they seem to be bigger and nearer.

Look at small print through a magnifying glass. Raise and lower the glass. What happens to the print?

What is a magnifying glass?

A magnifying glass is a *lens*. A lens is a transparent glass or plastic disc with curved sides.

The picture in the black frame opposite shows how a lens magnifies an object. Light rays reflected from the object at A are refracted as they pass through the lens. They meet at a point which is called the *focus*. It seems to the eyes that these rays come from B, and so, at B, there is an image which is larger than the object.

When you are using a magnifying glass, you should raise and lower it until you find a position for it which gives you the clearest image. This is called *focusing*. If you have focused a magnifying glass properly, your eyes are at the focus of the lens.

Using water as a lens

Fill a large round bottle with water. Lay it on a newspaper. The print is magnified because the curved surface of the water behaves as a lens.

Draw a head, facing to the right, on a postcard. Look at it through two jars of water. The head seems to face to the left and to be a little larger.

Spectacles, telescopes and microscopes

Spectacles are a pair of lenses which rest on a person's nose.

Telescopes make distant things seem to be bigger and nearer. A sailor uses a telescope to look at distant ships and the shore. The simplest kind of telescope has two lenses, one called the *eyepiece lens* and the other called the *object lens*.

Microscopes make small things seem to be much larger. A microscope has at least two lenses and works in much the same way as a telescope. Some microscopes will magnify very tiny things, such as disease germs, hundreds of times so that they can be seen clearly.

Using a telescope

Perhaps your teacher has a telescope which he will allow you to use.

Look at a distant object. Slide the tubes in and out. What does the distant object seem to do?

Look at the stars through the telescope. Do they seem to be larger? *Never look at the sun through a telescope.* If you did, you would damage your eyes.

Using a microscope

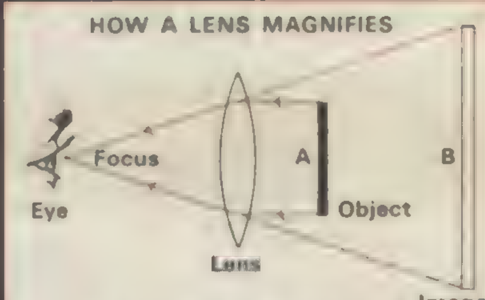
Examine a microscope. A microscope with its parts labelled is shown opposite.

Put a cotton thread on a glass slide and look at it under the microscope. Do the same with a drop of pond water, a hair, the leg of an insect, dust, a petal, etc. Raise and lower the eyepiece lens by turning the *focusing screw*.

MORE THINGS TO DO

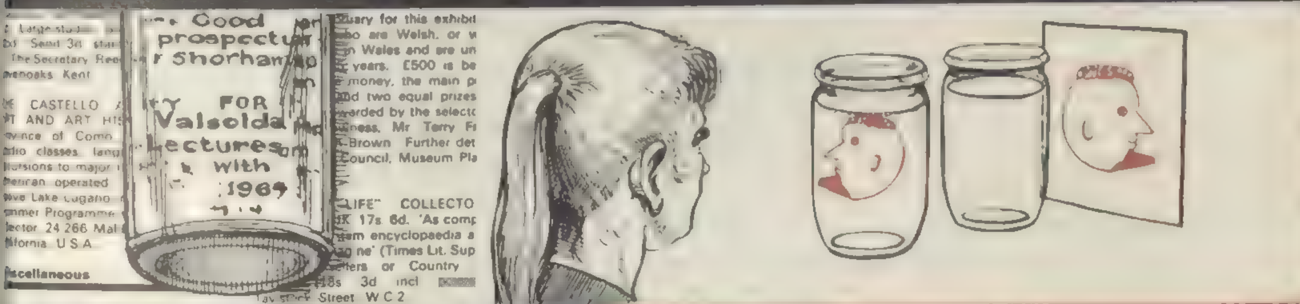
1. Copy the picture shown in the black frame opposite.
2. Draw a microscope. Label each part.

Bigger and nearer



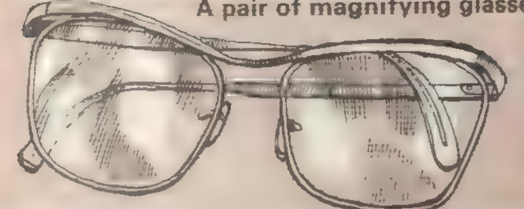
The rays from the object at A are refracted and seem to come from B. At B, there is an image which is larger than the object

USING WATER AS A LENS



SPECTACLES

A pair of magnifying glasses



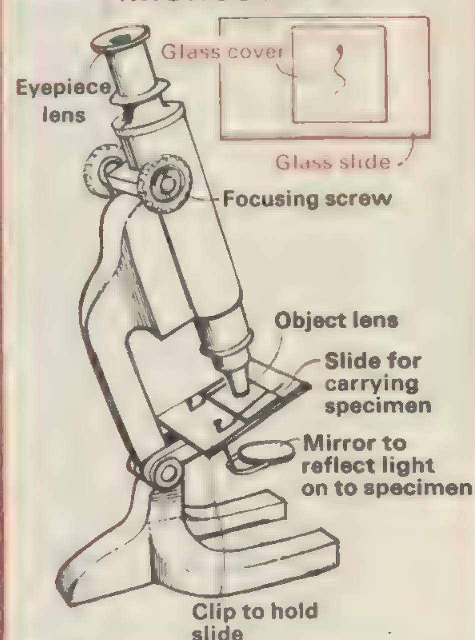
USING A TELESCOPE

Cotton thread

Tuberculosis germs

Lockjaw germs

Insect's leg



33 Colours in the sky

Rainbows

A band of beautiful colours that we call a *rainbow* is sometimes seen in the sky when the sun comes out after a shower of rain.

How is a rainbow caused? Raindrops, being round in shape, behave as tiny lenses and bend rays of sunlight. But, sunlight is *white light*, and white light is a mixture of colours – red, orange, yellow, green, etc. Some rays of colour are refracted more than others, and so when a ray of white light passes through a raindrop, it is split up and spread out into a band of different colours. *Red*, which is refracted the least, is at one end of the band, and *violet*, which is refracted the most, is at the other end of the band.

Small rainbows are often seen when the sun shines through a jug of water or oil floating on the surface of water.

The colours of the rainbow

There are 7 colours in the rainbow. They are *red, orange, yellow, green, blue, indigo* and *violet*. Indigo is a blue-violet colour in between blue and violet.

You will be able to remember the colours of the rainbow in their proper order quite easily if you learn this sentence. Say it aloud a few times.

Richard of York goes battling in vain.

You notice that the first letter of each word – *R, O, Y, G, B, I* and *V* – is the first letter of each of the names of the colours of the rainbow – *R*ed, *O*range, *Y*ellow, *G*reen, *B*lue, *I*ndigo and *V*iolet.

Making rainbows

Try to make small rainbows by shining a torch in different directions through each of these things.

1. A jar of water.
2. A glass ornament.
3. The edge of a thick mirror.
4. A little machine oil floating on the surface of some water in a dish.
5. A spray of water. You can make a spray of water by pressing your finger under a tap which has been turned on fully.

The colours in white light

Show that white light is really a mixture of colours.

Cut out a disc of thin card, about 8 centimetres wide. Paint the disc to show the colours of the rainbow.

Use a knife to scrape away the surface of a wooden meat skewer so that it will fit tightly in the hole in a bobbin. Push the skewer through the centre of the card and the hole in the bobbin to make a spinning top.

Spin the top quickly. You can try "starting" the top with a string "whip".

The colours mix together to give white. The white is "dirty" because the colours painted on the disc are not pure rainbow colours.

MORE THINGS TO DO

1. Draw 7 circles. Use a pencil and a penny to do this. Paint or crayon each circle with one of the rainbow colours and label it – red, orange, yellow, etc.

2. Copy this sentence. Underline the first letter of each word.

Richard of York goes battling in vain.

Colours in the sky

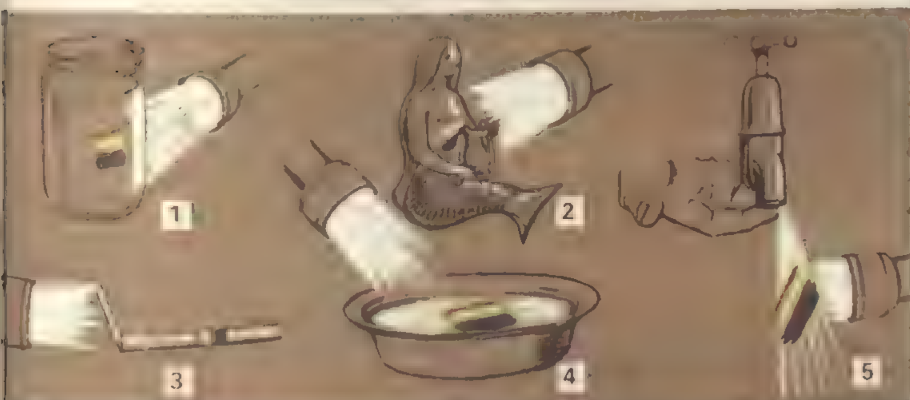
RAINBOWS

A raindrop splits up sunlight into 7 colours

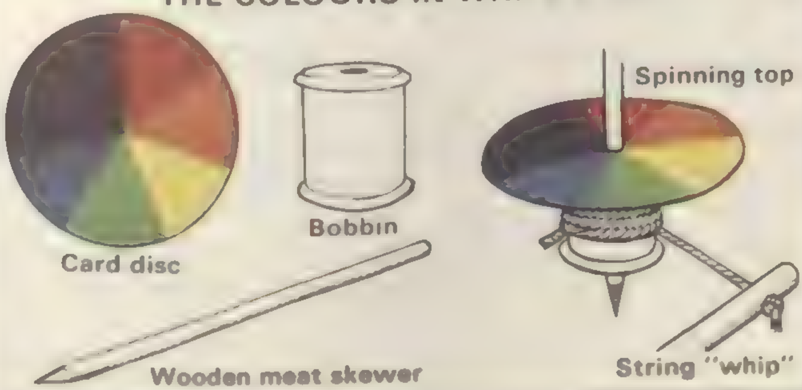
Jug of water

Oil on the surface of water

MAKING RAINBOWS



THE COLOURS IN WHITE LIGHT



THE COLOURS OF THE RAINBOW

Red

Orange

Yellow

Green

Blue

Indigo

Violet

Richard of York goes battling in vain

34 A box camera

Cameras

As you know, *cameras* are used for taking photographs.

There are many different kinds of cameras. Some are box-shaped. An early type of camera, called a "*mouse-trap camera*" because of its box shape, is shown on the page opposite. In some, there is a folding front which can be packed away inside a thin flat box. Cheap cameras are very simple. Expensive cameras have many gadgets. But, all cameras work in the same way.

If you are a beginner at photography, use a cheap box camera. It gives good results and there is little to go wrong.

How a camera works

A camera is a box which light cannot enter except through a small hole in the front. When a photograph is taken, this hole is opened for a short time and light rays from the things being photographed fall on to a *film* at the back of the camera. This film is coated with chemicals which are sensitive to light.

The parts of a camera

Open and examine an old-fashioned type of box camera. Look for the parts which are given in this list.

Aperture. Small hole which allows light rays to fall on the film.

Shutter lever. Shutter opens and closes the aperture.

Lens. Focuses light rays so that a clear bright image forms on the screen.

View-finder. Triangle-shaped piece of glass which reflects upwards a small image of the things being photographed.

Window. Shows the number of pictures which has been taken. Covered with red transparent plastic so that no white light can enter the camera and damage the film.

Roller knob. Turns the film roller.

Spool. Holds the used film.

Using the camera

Having first removed the back of the camera, cover the open end with a sheet of tracing paper. Place a lighted candle in front of the camera. Operate the shutter several times. Is the image of the candle seen only when the shutter is open? Why is the image upside down?

Can you see an image of the candle in the view-finder? Practise using the view-finder.

Taking photographs

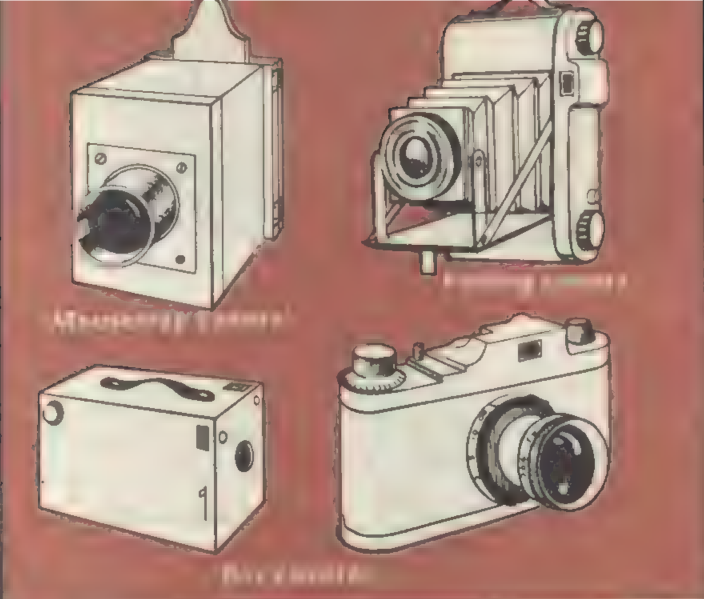
These rules will help you when you are taking photographs.

1. Load the camera with a roll of film of the correct size. Do not expose the film to the light. 2. Turn the roller knob until the window shows frame *No. 1*. 3. Choose a subject for a picture. The sun must be behind or at the side of the camera, otherwise the final picture will be black or blurred. 4. Hold the camera so that the subject is seen in the view-finder. 5. Keep the camera steady and operate the shutter. 6. Bring the next frame into position – *No. 2*. 7. When all the pictures have been taken, turn the roller knob until the window is empty. 8. Unload the film. It is now ready for *developing and printing*.

MORE THINGS TO DO

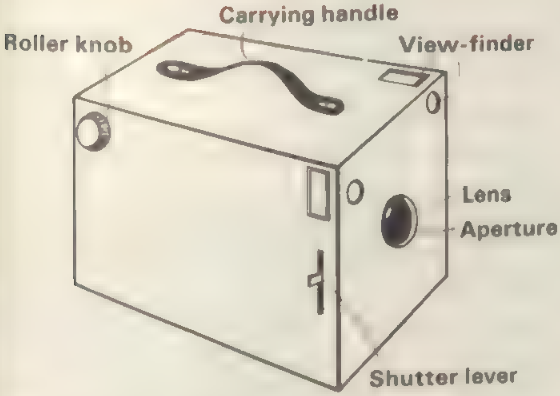
1. Draw a camera. Label each part.
2. Copy the rules for taking photographs.
3. Use an encyclopedia to find out what you can about *developing* and *printing*.

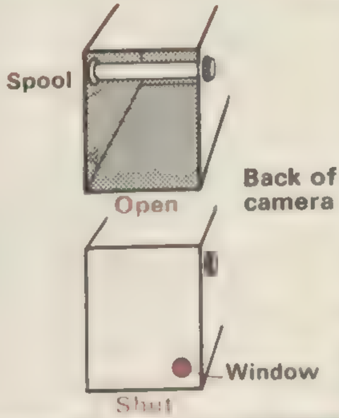
A box camera



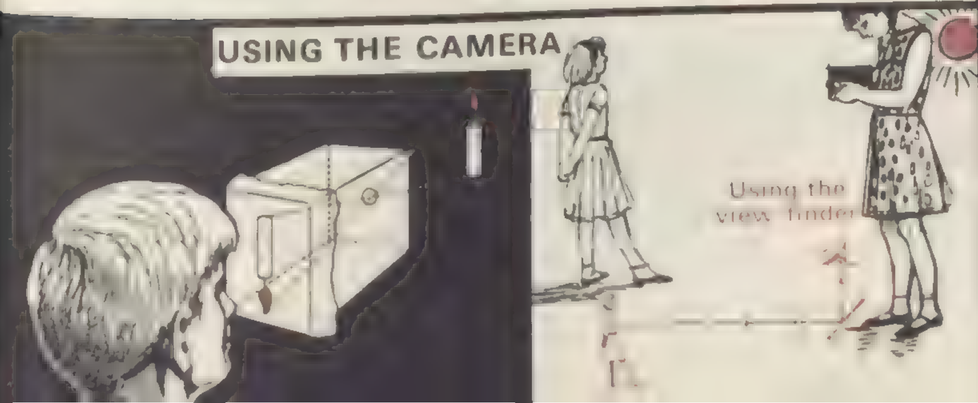
HOW A CAMERA WORKS

THE PARTS OF A CAMERA

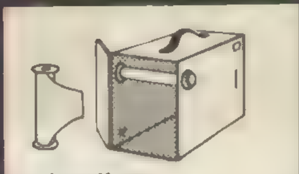




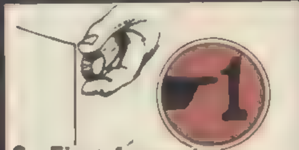
USING THE CAMERA



TAKING PHOTOGRAPHS

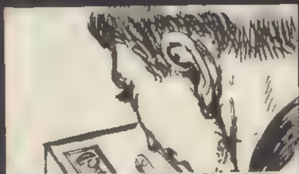


1. Loading



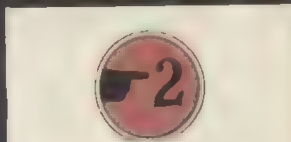
2. First frame in position

3. Choosing a subject

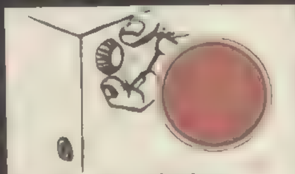


4. Using view-finder

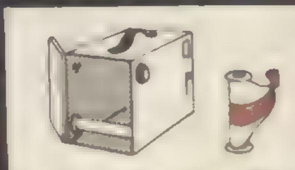
5. Operate the shutter



6. Second frame in position



7. Empty window



8. Unloading the film

35 The eyes

The eyes are cameras

The eyes are little cameras.

Compare a camera with an eye. Light rays enter a camera through a small hole, called the aperture, and are focused by a lens on to a light-sensitive film. Light rays enter an eye through a small hole, called the *pupil*, and are focused by a lens on to a screen of light-sensitive nerve endings, called the *retina*.

A human eye

A human eye, drawn so that you can see its parts, is shown opposite.

The impressions of the images on the retina are carried to the brain by the *optic nerve*. The place where the optic nerve joins the retina is called the *blind spot* because it is not sensitive to light.

The pupil is a circular hole in the *iris*. The iris covers the lens and is the part of the eye that is coloured blue, brown, grey, etc. The iris alters the size of the pupil. The pupil becomes smaller in bright light. This prevents too much light falling on the retina. The pupil becomes larger in dull light so that the eye can make the most of the light that is available. When you go out of the sunshine into a dark room, you can see nothing at first because the pupils of your eyes are still small.

The front of the eye is protected by a transparent skin. It is kept clean by the wiping action of the upper eyelid.

Looking at an eye

Examine one of the eyes of a friend. Look for the eyebrow, eyelids, eye-lashes, pupil, iris and eyeball. What is the colour of the eyeball? What is the colour of the iris? Notice the frequent and rapid movements of the upper eyelid.

Ask a friend to close his eyes for a few seconds. When he opens them, the pupils are large; they soon become small.

Shine a torch on his eyes. The pupils become smaller.

Finding the blind spot

Hold this book so that the cross and the circle on the page opposite are about 50 centimetres away from your eyes. Shut your left eye and look at the cross with your right eye. Bring the book closer until the circle disappears. The image of the circle is then focused on the blind spot.

Why do we have two eyes?

You have *binocular vision*. This means that you have two eyes which, in giving you two slightly different views of the same object, enable you to judge its distance. An object seen with one eye lacks depth; it seems to be "flat".

Binocular vision

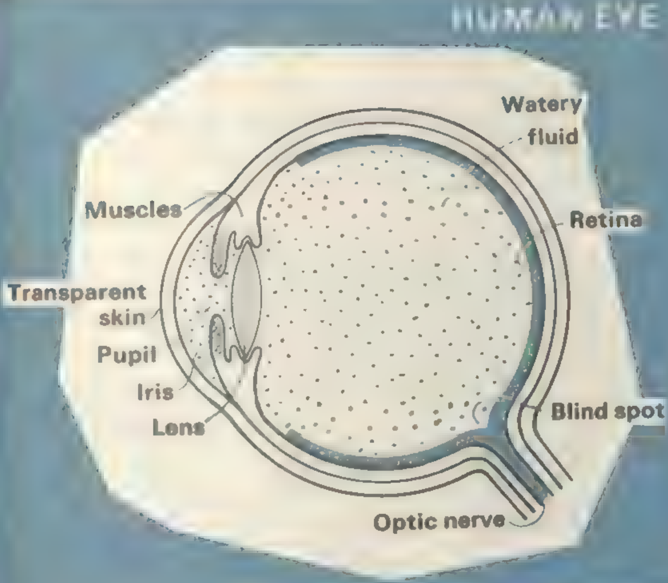
Close one eye and try to bring together the points of two pencils, one held in each hand. Do this again with both eyes open. Can you judge distances better with two eyes?

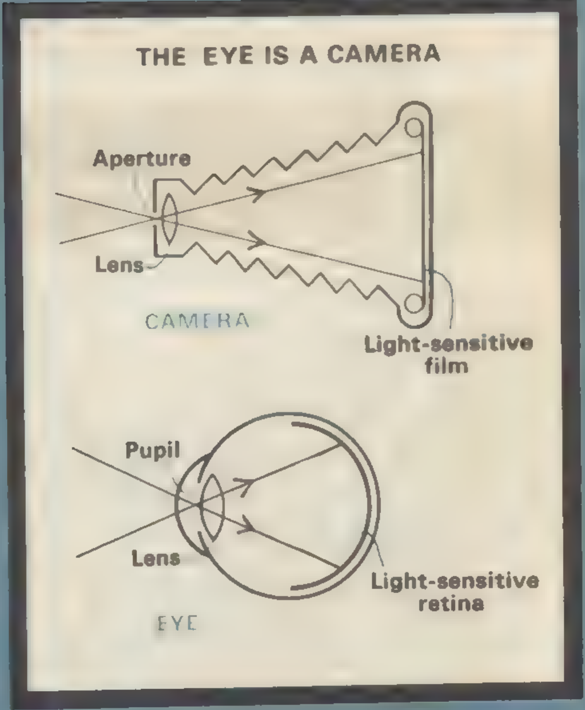
Close your right eye and hold a pencil upright at arm's length and in line with the edge of a picture on a wall. Now, close your left eye and open your right eye. The pencil seems to move to the left. Why?

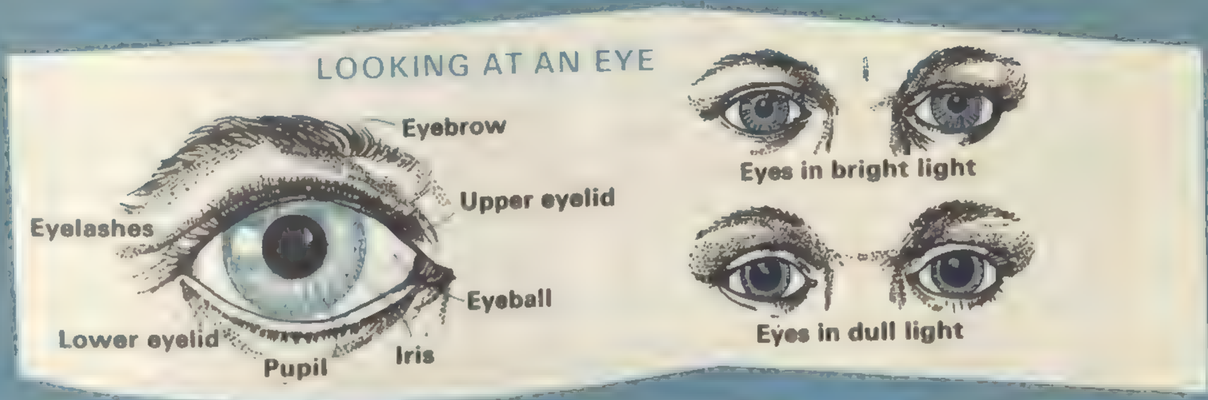
MORE THINGS TO DO

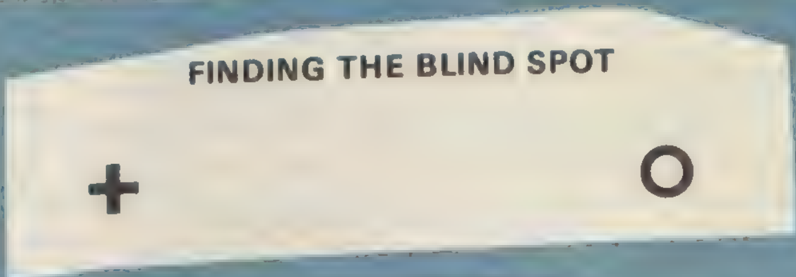
1. Copy the drawings shown in the black frame opposite.
2. Write a few sentences about the eyes.

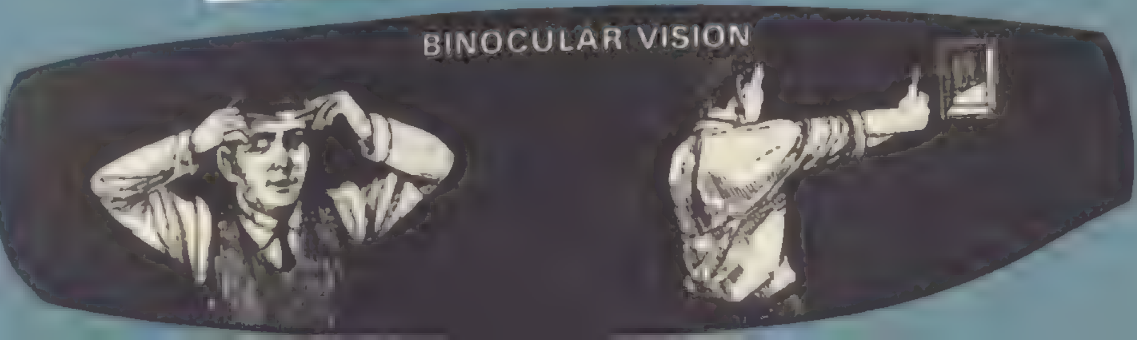
The eyes


HUMAN EYE
Watery fluid
Muscles
Retina
Transparent skin
Pupil
Iris
Lens
Blind spot
Optic nerve


THE EYE IS A CAMERA
Aperture
Lens
CAMERA
Light-sensitive film
Pupil
Lens
Light-sensitive retina
EYE


LOOKING AT AN EYE
Eyebrow
Upper eyelid
Eyelashes
Eyeball
Lower eyelid
Pupil
Iris
Eyes in bright light
Eyes in dull light


FINDING THE BLIND SPOT


BINOCULAR VISION

36 At the cinema

Moving pictures

The people on the screen at the cinema move about as if they were alive. How are the pictures made to move?

The main parts of a *cinema projector* are shown opposite.

A beam of light from a powerful lamp passes through a picture on a transparent film. The picture is magnified by a lens and a very large image is projected on to a screen.

The long film of pictures, which is carried on two *spools,* is pulled through a *gate* behind the lens by *claws* and *sprocket wheels. Teeth* on the sprocket wheels fit into small holes along the edges of the film. A *shutter* shuts off the light to the gate during the time when a new picture is moving into position. This action is very rapid and so a series of pictures, each slightly different from the previous one, is projected separately and in quick succession on to the screen. This series of still pictures appears as a single, moving picture because of *persistence of vision.* The eyes and brain hold the impression of a picture for at least 1/24 of a second; each picture seen merges with the impression of the previous picture seen. Really, the eyes are being deceived.

Using a projector

Perhaps your teacher will show you a projector in operation.

Look at a piece of film. Do you know why the pictures are upside-down and the words are printed backwards?

Persistence of vision

Tie a key on to the end of a string and whirl it round and round. Why does the whirling key seem to make a silver circle in the air?

Draw a goldfish bowl on one side of a postcard and a goldfish on the other. Make two holes at the top and the bottom of the card and thread loops of string through them. Hold the ends of the loops and turn the card many times so that the strings are twisted. Let go the card. The untwisting strings cause the card to turn rapidly. The goldfish appears to be in the bowl because of persistence of vision.

An after-image

Stare hard for at least a minute at the tree shape shown opposite. The shape is white on a black background. Then, look at a white wall or ceiling. You will see a black or grey tree shape on a white background. This is known as an *after-image*. It is a good example of how our eyes can sometimes deceive us.

A bird in a cage

Stare hard for a few seconds at the bird and the cage shown opposite. Then, bring the book towards your eyes. The bird seems to fly into the cage. Do you know why?

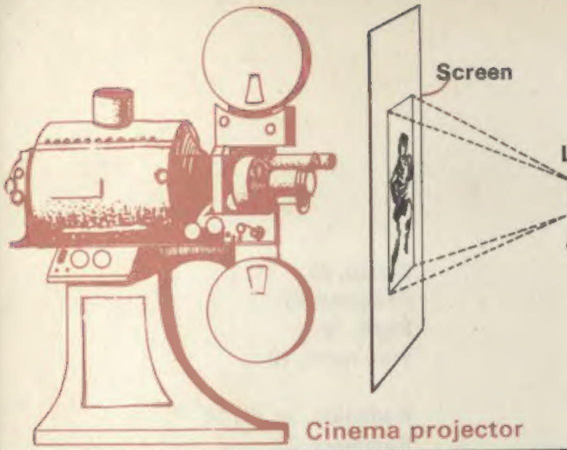
Optical illusions

Some ways in which our eyes can be deceived are shown opposite. They are called *optical illusions*. Can you explain them?

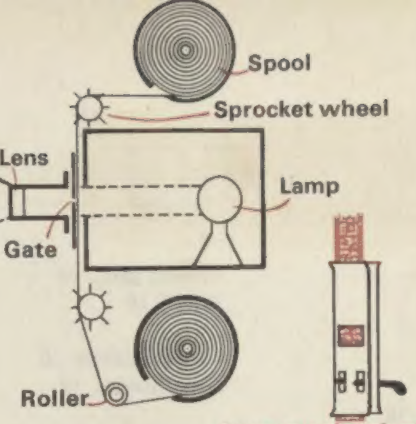
MORE THINGS TO DO

1. Write a few sentences about a cinema projector.
2. Make a *pocket cinema* in the way shown opposite. You can do this at home.

At the cinema

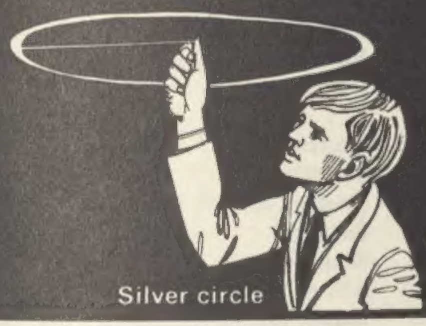


Cinema projector

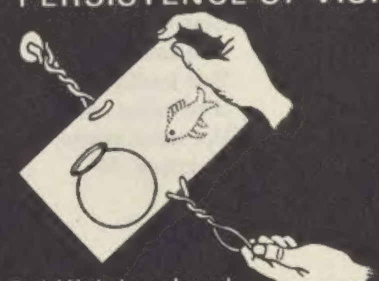


Gate mechanism

PERSISTENCE OF VISION



Silver circle

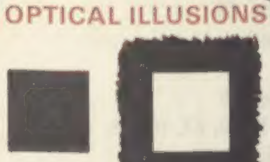


Goldfish in a bowl

AFTER-IMAGE

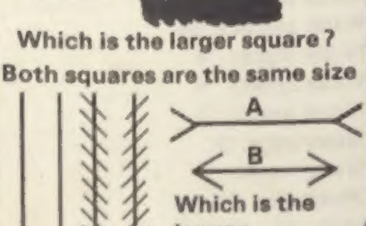
BIRD IN A CAGE

OPTICAL ILLUSIONS



Which is the larger square?

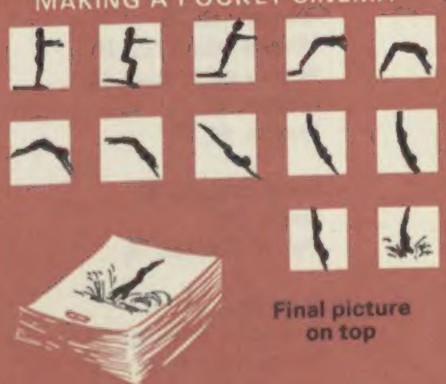
Both squares are the same size



Which is the longer line – A or B?

The second set of lines does not appear parallel. Why?

MAKING A POCKET CINEMA



Final picture on top

Draw about 60 pictures, each one slightly different from the previous one, on 5 cm squares of thick paper. Hold the squares together with a long paper fastener to make a book. Flick the pages of the book and you will see a moving picture. Why?

PIECE OF FILM

Why are the words printed backwards

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